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ORIGINAL ARTICLES.

I.—On Fossil Isopods, with a Description of a New Species.

By James Carter, F.G.S.

(PLATE VI. Figs. 1—7.)

THE recent discovery in the Woodwardian Museum of an undescribed species of Isopod from the Upper Greensand of Cambridge affords an opportunity for the revision of the entire list of that class of fossils. The total number of species which have hitherto been described as occurring in a fossil state is inconsiderable,—probably scarcely thirty—including both foreign and British. To what extent this small number expresses the variety of specific form of this tribe of Crustaceans, which actually existed during the period of deposition of the several rocks in which their remains occur, it is impossible to determine, as doubtless by far the greater proportion of the individuals perished by reason of the delicacy of their tissues—the larger and thick-shelled species only having been preserved—the small, thin-shelled kinds not admitting of recognizable "fossilization." Specimens of Jurassic and Cretaceous Isopods are very rare both as to variety and individual number, and it may be inferred that this rarity of occurrence results from the more or less turbulent conditions under which these marine deposits were formed. The Tertiary estuarine and freshwater species, buried under more tranquil conditions, are much better preserved, and occur in some localities in innumerable abundance—*Sphæroma*, *Archæoniscus*, etc.

The succession and geological distribution of Isopods, so far as has yet been ascertained, is indicated by the following list:—

One species	has been obtained form	the Old Red Sandstone.
? One "	"	the Triassic rocks.
Five "	"	the Jurassic "
Three "	"	the Cretaceous "
Eighteen	"	the Tertiary "

About three-fourths of the forms enumerated are foreign, and seven species have been recorded by Dr. Woodward as occurring in this country:—

Præarcturus gigas, H. Woodw.	Old Red Sandstone, Hereford.
Archæoniscus Brodiei, Milne Edwards	Purbeck Beds, Vale of Wardour.
" *Edwardsii*, H. Woodw.	" "
Palæga Carteri, H. Woodw.	Grey Chalk, Dover.
Bopyrus sp. (parasitic)	Greensand, Cambridge.
Eosphæroma fluviatile, H. Woodw....	U. Eocene, Isle of Wight.
" *Smithii*, H. Woodw.	" "

To this list may be added *Palæga McCoyi*, the new Cretaceous form described in this paper, thus making a total of eight species as representing the fossil Isopods in Britain. In Phillips's Geology of Oxford and Valley of the Thames, p. 122 (1871 ed.), the genus *Ægа* is mentioned in a list of Liassic fossils, but no specific name, figure or description is given.

In investigating a tribe of genera it is obviously desirable not only to consider each genus separately and distinctly, isolated from its allies, but also to consider it with reference to other forms, so as to determine its relationship and phylogeny, and the precise zoological position which it occupies. To do this at all completely is as difficult as it is interesting, even with reference to living organisms; but with regard to those which occur only in a fossil, and consequently in a more or less imperfect, condition, the difficulty is increased; and in the case of the Isopods—as indeed in that of the innumerable host of perishable organisms which doubtless existed in geological periods—it is well-nigh hopeless to attempt such an enquiry, inasmuch as the supply of material in the shape of specimens is so extremely limited. It may, however, be useful to give collectively a brief epitome of the publications of the few palæontologists who have written upon the subject up to the present date.

In 1879 Dr. H. Woodward, who is well known to have long given special attention to, and to have contributed so largely towards a knowledge of, fossil carcinology generally, made a valuable communication to the Geological Society (Q.J.G.S. vol. xxxv.), in which he has given a list of described species of Isopoda, including the seven already alluded to as being British, and seven foreign; and has added copious notes and observations.

Dr. Ludwig von Ammon, of Munich, has published an able and exhaustive paper—"Ein Beitrag zur Kenntniss der fossilen Asseln" (Sitzungsber. d. Math.-Phys. Classe der k. k. Akad. d. Wissensch. 1882, Heft iv.), in which he has described a new species of *Palæga* (*P. scrobiculata*), and critically reviewed, with abundant bibliographical references, the contributions of various authors who have written upon Isopods. He has also compiled a table, systematically and stratigraphically arranged, of all the species which he regards as true Isopods, including those which Dr. Woodward had previously enumerated, and adding the ten following:—

Isopodites triassicus, Picard, Trias. (A doubtful form.)
Urda rostrata, Münst. Solenhofen.
,, *punctata*, ,, ,,
Ægites Kunthi, v. Ammon ,,
Palæga scrobiculata, v. Ammon, Tertiary.
From the "Unter oligocaen," Tyrol; a large species very nearly allied to *Palæga Carteri*, Woodw.
Oniscus convexus, Koch und Berendt, Tertiary (in Amber).
Trichoniscus asper, Menge, ,,
Porcellio notatus, Koch und Berendt, ,,
,, *granulatus*, Menge, ,,
,, *cyclophorus*, Menge, ,,

The five last mentioned are terrestrial Oniscidæ, of small size, and nearly allied to recent forms. A new Mexican species of

Sphæroma (*S. Burkartii*, Barc.), is described by M. Barcena (Geological Record, 1875, p. 297). The GEOLOGICAL MAGAZINE for April, 1887 (Vol. IV. p. 189), contains a notice of a paper "On New Neogene Isopoda," by N. Andrussow, in which mention is made of the following:—

Cymodocea Sarmatica, Andr. A marine genus of the Sphæromidæ.
Palæga Anconitana, Andr.
Sphæroma Catullii, Zigno.
,, *exsors*, Eichw. Bull. de Moscou, 1863.
Cymatoga Jazykowii, Eichw. Cretaceous, Bull. de Moscou, 1863.

Lastly, let me add that Prof. K. A. von Zittel (Handbuch der Palæontologie, 1885, pp. 666—670) gives, besides the foregoing:—

Arthropleura ornata, Jordan, Coal-M. Saarbrücken.
Archæosphæroma Frici, Novak, U. Miocene, Bohemia.
Sphæroma faveolatum, Costa, Post-Tertiary, Calabria.
Armadillo molassicus, H. v. Meyer, U. Miocene, Oeningen in Baden.

On *Palæga McCoyi*, sp. nov. Plate VI. Figs. 1—7.

The species about to be described is represented by three specimens from the Cambridge Upper Greensand, one of which exhibits the cephalon and first two segments of the pereion, another is tolerably complete except the telson, the third consists of portions of the pereion, the pleon, and the telson, with traces of the caudal appendages. As is the case with so many of the fossils from the same prolific bed, the specimens occur as phosphatic casts only, no portion of the test having been preserved: these casts are, however, so sharp as to afford characters with quite sufficient distinctness to be available for specific description. As specimens of Isopods occur so rarely, and are usually so imperfect, the distinction of a new species by means of mutilated examples seems justifiable.

Description.—General form slender, moderately convex transversely; lateral margins of pereion approximately parallel; cephalon about three-fourths as wide as the first segment of the pereion, rather wider than long, rounded in front, posterior border with a median condyloid prominence. Eyes large, reniform, widely separated, directed obliquely outwards and forwards; extending backwards beyond the transverse mid-line of the cephalon. The three anterior segments of the pereion rather shorter than the succeeding four; a sharp sulcus marks off a large epimeron on each segment. The pleon is about half the length of the pereion, and rather narrower; it consists of five equal, short segments, the last of which is lodged in the sinus of the fourth. The telson constitutes the posterior half of the pleon, and is as wide anteriorly as the segment which supports it: it narrows posteriorly and has apparently no carina. The surface of all the segments may be seen under the lens to be pitted by large, widely separated, puncta (see Pl. VI. Figs. 4 & 5). The matrix in which the specimen is embedded shows a sharp cast of the uropodite, the basal joint of which has the inner distal angle prolonged into a spine more than half as long as the endopodite—a character which occurs in many *Ægidæ*: the endo- and exo-podite are broken; they were probably of moderate and of equal size.

Total length from 30 to 35 millimetres; width from 8 to 9 mm. Upper Greensand, Cambridge; Woodwardian Museum.

To one of the specimens (Figs. 5 and 7) Prof. Seeley attached as a MS. label *Squilla McCoyi*, and this name is quoted by Mr. Jukes Browne in the list of fossils contained in his paper 'On the Cambridge Gault and Upper Greensand' (Q. J. G. S. May, 1875). The subsequent occurrence of two other specimens has enabled me to determine that the fossil so named is the pleon of the Isopod now described.

Palæga McCoyi is quite distinct from all other described fossil Isopods, although it bears considerable resemblance to several recent forms. I have provisionally referred it to the genus *Palæga*, established by Dr. H. Woodward (Geol. Mag. 1870, p. 495). Some characters suggest a reference to the recent genus *Cirolana*, but the tribe to which it really belongs cannot be determined until the details of the cephalic and abdominal appendages are known; in the absence of this knowledge it is not possible to decide whether it should be referred to the Ægidæ proper, or to the Cymothoidæ.

With reference to these tribes, as regards living species, a most valuable and exhaustive series of articles, illustrated by numerous plates, have been published in Naturhistorisk Tidsskrift (Copenhag.), Bd. xii. xiii. xiv. 1879–84, 'Symbolæ ad Monographiam Cymothoarum,' by J. C. Schiœdte and Fr. Meinert. These authors also publish a paper in the same series, 'De Cirolanis Ægas simulantibus commentatio brevis,' Bd. xii. 1879–80.

DESCRIPTION OF PLATE VI. Figs. 1—7.

Fig.	2.	*Palæga*	*McCoyi*,	Carter.	Showing the cephalon (crushed), the pereion, and the anterior segments of the pleon. nat. size.
,,	1.	,,	,,	,,	Cephalon, first, and portion of second segment of pereion. nat. size.
,,	4.	,,	,,	,,	The same specimen as Fig. 1, but enlarged.
,,	7.	,,	,,	,,	Posterior portion of pereion, the pleon and the telson, with impression in the matrix of uropodite. nat. size.
,,	5.	,,	,,	,,	The same specimen as Fig. 7, but enlarged.
,,	6.	,,	,,	,,	Uropodite. enlarged.
,,	3.	,,	,,	,,	Restoration of entire form.

II.—On the Microscopic Structure of the Jurassic Pisolite.

By E. Wethered, F.G.S., F.C.S., F.R.M.S.

(PLATE VI. Figs. 8—11.)

THE specimens of pisolite which I have examined were obtained from two horizons, namely, the Coralline Oolite and base of the Inferior Oolite near Cheltenham. The pisolites are well known and have frequently been referred to by authors as fine types of oolitic granules, and in proof of this I may quote from Mr. H. B. Woodward's last edition of his Geology of England and Wales. Speaking of oolite granules the author says (p. 281), "When these

particles approach the size of a pea or bean, the rock is termed Pisolite, Pisolitic Limestone, or Pea-grit."

The Coralline Pisolite.

For the specimens which I have examined from the Coralline Oolite and for information descriptive of the beds, I am indebted to Mr. H. B. Woodward, F.G.S., to whom I return my cordial thanks. The first specimens sent me were collected at Osmington, near Weymouth, from a bed 1 foot thick, and occurring 6 or 7 feet from the base of the Coralline division, named "Osmington Oolite" by Blake and Hudleston.[1] The specimens consisted of dark brown calcareous spherules about the size of peas. They were loosely embedded in an argillaceous matrix in which there were also oolitic granules of the ordinary size and type.

The sections of the spherules show a nucleus in each, but the structure of the surrounding material can only be studied through a microscope. Viewed through a low power the nucleus is observed to be enclosed by rudely concentric layers of innumerable minute tubuli. Examined by a half-inch object glass the tubuli are clearly defined. They measure about $\frac{1}{4000}$ of an inch in diameter, and are remarkable for the extraordinary vermiform twistings and turnings which they exhibit, Fig. 9, Pl. VI. They appear to make up the whole mass; no skeleton fibre can be made out, and what spaces there are between the tubuli are filled with crystalline calcite. The only system exhibited by the tubuli, if system it can be called, is that they appear in aggregations, having a concentric tendency around an unoccupied space in the centre of each aggregation, and that the latter seem to interlace one with the other. The other specimens sent me by Mr. Woodward were collected at Sturminster Newton, from the bed No. 6a. mentioned by Blake and Hudleston.[2] The horizon is the same as the Osmington pisolite, and the bed is described as consisting of "loose pisolite of large flattened concretions, 1 foot thick." In shape and size the spherules are similar to those from Osmington, but they are lighter in colour. The microscopic structure is generally well preserved and coincides with the description given of the Osmington pisolite.

Pisolite, or Pea-grit, from the Inferior Oolite. Pl. VI. Fig. 8.

After examining the specimens of pisolite from the Coralline Oolite I turned to the Pea-grit, so well known as occurring at the bottom of the Inferior Oolite in the Northern Cotteswolds. The greatest development is in the neighbourhood of Cheltenham, and the stratigraphical features of these interesting beds have been frequently referred to by geologists; among whom I may mention Sir R. Murchison, Mr. Strickland, Dr. Wright, Professor Hull, Mr. Lycett, Professor Buckman, Mr. Witchell, Mr. Etheridge and Mr. Lucy.

[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 265.
[2] *Loc. cit.* p. 276.

Dr. Wright[1] divided the beds as they occur at Leckhampton near Cheltenham as follows, in descending order:

"A. Brown, coarse, rubbly oolite, full of flattened concretions, cemented together by a calcareous matrix.	12 feet
"B. A hard cream-coloured pisolite rock made up of flattened concretions of about the thickness of those in A.	10 "
"C. A coarse, brown, ferruginous rock composed of large oolitic grains	20 "
Total	42 feet"

Commencing the microscopic examination at the beds marked C by Dr. Wright, we see a limestone made up of granules and fragments of organisms, the spaces between being filled in with crystalline calcite. The organic fragments consist of spines of Echini, Polyzoa, Crinoids, shells of Mollusca and Foraminifera, those of the Crinoids and Echini are by far the most numerous. All the granules show a nucleus, but in some instances the original has become converted into crystalline calcite. The nuclei vary, indeed all the fragmentary remains of organisms mentioned as occurring in the rock may be said to serve. When the nucleus is a portion of a spine, then the shape is less spherical and is somewhat elongated.

The granules are of two types; first the true oolitic granule distinguished by the concentric layers; second, spherules which vary in size from that of ordinary oolitic granules to that of a pea. In this latter type of spherule the nucleus is not surrounded by concentric layers of carbonate of lime, but by vermiform tubuli averaging about $\frac{1}{500}$ of an inch in diameter (Figs. 10-11), but in some instances they are larger. The tubuli may be said to be arranged in layers or bands which are concentric with the nucleus. In some instances the tubes turn and twist about in a very remarkable manner, sometimes assuming a flat spiral form.

Passing to the succeeding series of beds, marked B by Dr. Wright, we find the pisolite spherules[2] as large as peas (Fig. 8, Plate VI.), but often flattened. The typical Pea-grit is confined to one bed which averages about 4 feet 6 inches thick, and is best studied at Cleeve Hill. It is a mass of the spherules, which are firmly cemented in the matrix. On exposure to the action of the atmosphere the matrix is removed and the spherules then stand out in relief and after a time become detached. On examining some of these with a magnifying glass a vermiform structure may be noticed in some instances.

Thin sections made from this typical bed show the nucleus in the spherules to be surrounded by the same tubuli as represented in Figs. 10 and 11, but if anything they are more vermiform. Some of these spherules, however, show layers and spaces not occupied by that type of tubuli, and when these are not filled with crystalline material, minute tubuli are seen which correspond with those in the pisolite from the Coralline Oolite.

[1] Quart. Journ. Geol. Soc. vol. xvi. p. 7, 1860.

[2] I use the term spherule for the pisolites and granule for the ordinary oolitic forms.

Inference.

I now come to the inference which is to be drawn from the observations I have made. The first conclusion, which cannot be disputed, is, that we can no longer regard the pisolites as a form of concretionary oolitic structure. The so-called pisolite granules are really formed by the growth of an organism around a nucleus. As to the determination of that organism the similarity to the genus *Girvanella* is at once suggested. This organism was first described by Professor A. Nicholson and Mr. R. Etheridge, jun.,[1] and has since been more fully referred to by Professor Nicholson.[2] He remarks, "This curious fossil occurs in great numbers in the lime-formation of the rock," the Ordovician limestone, "and presents itself in the form of small rounded or irregular nodules which vary in diameter from less than a millimetre to more than a centimetre. The larger examples show a distinctly concentric structure, visible even to the naked eye, but the most powerful lens fails to show any obvious internal structure in fractured or weathered surfaces. Examined microscopically the nodules of *Girvanella* are seen to consist of exceedingly minute circular tubes, endlessly contorted and bent, and twisted together in loosely reticulated or vermiculate aggregations." This description of the microscopic structure of *Girvanella problematica*, the one species of the genus mentioned by Professor Nicholson and Mr. Etheridge, jun., corresponds very closely with the structure of the Coralline pisolites, and with the minute tubuli in some of the Pea-grit spherules at the base of the Inferior Oolite. A comparison of actual specimens confirms the similarity, and I have no hesitation in referring the Coralline pisolites to the genus *Girvanella*. Nor do I find sufficient evidence to warrant me in making a new species. It is true that the majority of the tubes are smaller than those in *G. problematica*, and that Professor Nicholson makes no reference to a nucleus around which they congregate. Now, the first portion of a Jurassic *Girvanella* spherule to undergo change is the nucleus. In some specimens we find simply crystalline calcite into which the original nucleus has been converted. The Silurian rocks, in which *Girvanella* was first discovered, are so much older than the Jurassic Oolite that it is not surprising to find the original nucleus changed into crystalline calcite. In the specimens which I have examined of *G. problematica* there seems to me to be undoubted signs of a nucleus, and I therefore do not see my way to make the absence of a clearly defined nucleus in the Silurian forms the reason for proposing another species of those in the Coralline Oolite, but it is possible that at some future time evidence may be obtained which would warrant that course being taken for reasons apart from the nucleus.

With some of the spherules of the Pea-grit the matter is different. The larger well-defined tubuli represented in Figs. 10 and 11 are wanting in the Coralline forms, and I therefore propose to give them the name of *Girvanella pisolitica*. It is a question whether

[1] Mon. Sil. Foss. Girvan, pp. 22-3. pl. ix.
[2] Geol. Mag. N.S. Dec. III. Vol. V. p. 22, 1888.

two species should not be made out of the Pea-grit forms, on account of both the minute tubuli and the larger type occurring in the same spherule. For the present, however, I do not see my way clear, as it may be that the two forms are associated together in the same spherule.

As to what known organisms *Girvanella* should he referred is a matter which seems to me to be one of considerable difficulty. Professor Nicholson and Mr. R. Etheridge, jun., referred it to the *Rhizopoda* and regarded it as related to the arenaceous *Foraminifera*. From this view Professor Nicholson, in his later communication, sees no reason to depart (*loc. cit.* p. 23).

Girvanella pisolitica (new species), Plate VI. Figs. 10 and 11.

This species occurs in the form of flattened spherules varying in size from 1 to $\frac{5}{12}$ of an inch in greatest diameter (Fig. 8, Plate VI.). In the centre of each spherule there is a nucleus which is surrounded by calcareous tubuli (Figs. 10 and 11) with well-defined walls, and averaging about $\frac{1}{500}$ of an inch in diameter, though some are smaller. In some instances, more especially in the larger spherules, the tubes bend and twist about in a truly vermiform manner, often assuming the form of a flattened coil. It differs from *G. problematica* inasmuch as the tubes do not occur in aggregations, and are more concentric around the nucleus. The tubes are also branching and are larger than those of *G. problematica*.

DESCRIPTION OF PLATE VI. Figs. 8—11.

Fig. 8. Spherules of *Girvanella pisolitica* from the Pea-grit near the base of the Inferior Oolite, Cheltenham. Natural size.

Fig. 9. Portion of *Girvanella problematica* from a Coralline Oolite spherule. × 68 diam.

Fig. 10. *Girvanella pisolitica*, shown in section, from near the base of the Inferior Oolite near Cheltenham. × 40 diam. (not 50 diam. as erroneously marked on the plate).

Fig. 11. Another spherule of *Girvanella pisolitica* from the Pea-grit near Cheltenham. × 30 diam. Shows a joint of a Crinoid as a nucleus.

III.—On Jurassic Ammonites.

By S. S. Buckman, F.G.S.

Ammonites serpentinus (Reinecke), and Ammonites Strangewaysi, Sowerby.

In a former communication (Geol. Mag. Dec. III. Vol. IV. No. 9, p. 396, 1887), when pointing out how Reinecke's *Amm. serpentinus* had been misunderstood, I gave as a synonym, but with a query, Sowerby's *Amm. Strangewaysi*. As I have, since then, examined the type-specimen of the latter species contained in the collection of the Natural History Museum, and as Mr. E. Walford kindly forwarded me for my determination a capital specimen from Byfield, I have been able to satisfactorily settle the identity of these forms. Except being evolute carinate Ammonites, the two species have hardly a feature in common.

Harpoceras Strangewaysi (Sowerby).

1822. *Ammonites Strangewaysi*, Sow. Min. Conch. pl. 254, figs. 1 and 3.
1885. *Harpoceras serpentinum*, Thompson (non Reinecke), Upper Lias; Journ. Northampt. Nat. Hist. Soc. vol. iii. p. 309, pl. 1, fig. 1.

Discoidal, compressed, hollow-carinate. Whorls flattened, ornamented with genuine sickle-shaped ribs, which, though less conspicuous in size on the body-chamber, are there more distinctly bent. Ventral area marked by the prolonged forward sweep of the ribs, and surmounted by a well-marked hollow-carina. Inner margin almost upright, neither concave nor convex. Umbilicus shallow and open. Inclusion, with the body-chamber present, one-third. Termination of mouth-border partly visible, showing that it is plain, and curved like the ribbing. Aperture, oblong.

The above, taken from Mr. Walford's specimen, differs in some particulars from Sowerby's description; but then neither Sowerby's figure, nor his description, agree with the original specimen. The umbilicus is drawn considerably too large; the inner margin—"oblique flattened surface which forms the inner edges of the whorls"—which Sowerby emphasizes so particularly, is by no means slanting, but is nearly upright, and the sectional view which he gives is quite incorrect. The ribs, too, are not drawn with sufficient bend; they are truly of the shape of a sickle, with the inner portion quite straight and a marked bend at the middle. The indications of suture-lines are correct enough in Sowerby's figure, and his specimen shows that the lobes are exactly those of *Harpoceras*, as I described these in my former communication (p. 397).

Harpoceras Strangewaysi differs from *Harp. falciferum* by its umbilicus being much more open—about one-fourth larger—its ribs not quite so strongly bent, and its inner margin almost upright instead of being undercut. Individual specimens of this species seem to differ in the coarseness of their ribbing. Sowerby's example is more coarsely ribbed than his drawing would lead us to expect.

Mr. Walford's specimen came from the "Fish-bed, Upper Lias, Byfield"; Mr. Thompson sent me a specimen from Bugbrook; and I have a poor example from Trent near Yeovil; Sowerby's specimen came from Ilminster. The species seems to be unknown on the Continent.

Hildoceras serpentinum (Reinecke).

1818. *Argonauta serpentinus*, Reinecke, Maris protogæi, figs. 74, 75.
1867. *Ammonites serpentinus*, Meneghini, Monogr. calc. rouge; Paléont. Lombarde, 4e série. Plate iii. fig. 1.
1885. *Hildoceras serpentinum*, Haug, Beitr. Mon. Harpoceras; Neues Jahrbuch für Mineral. Beil.-Bd. iii. p. 643.

I discussed this species in my previous communication (p. 396), pointing out wherein it differed from a species to which this name had been erroneously applied. I was uncertain, then, as to its genus, because I had not a specimen; and *Am. Strangewaysi* being given as a synonym misled me.

The suture-line[1] of this species differs entirely from *Harp. Strangewaysi*; it lacks all the florid ornamentation, the large accessory lobe, and the auxiliary lobe; in fact, the suture-line is an almost exact copy of what belongs to *Hildoceras bifrons*. The ribs incline more to a sigmoidal curve, the inner margin is actually obliquely-truncated, and inclining to be concave; the carina is solid and bounded by two slight furrows (which, however, disappear on the body-chamber); the inclusion is almost nil, and the whorls are consequently narrow. The difference betwen the suture-line of *Harp. Strangewaysi* and *Hildoceras serpentinum* is so striking that any one who has seen the two species together would never mistake them.

Hild. serpentinum is very like *Hild. bifrons* in all respects, but lacks the longitudinal furrow; while it has smaller ventral channels, and its ribs are visible on the inner area.

The species is evidently extremely scarce both in England and on the Continent. I have searched both the Natural History and Jermyn Street Museums without success; and the only specimen I know is the one in my own collection from South Petherton, probably from the *Falciferum*-zone.

Neither this nor the previous species were figured in Wright's monograph.

Ammonites Murchisonæ, Amm. corrugatus, Amm. læviusculus Sowerby; Harpoceras amaltheiforme, Vacek.

The first three species have usually been united under the name *Amm. Murchisonæ*; but this arose from the fact that the two species suppressed had never been correctly identified. I was soon able to satisfy myself concerning the species to which Sowerby had given the name *Amm. læviusculus*; but the little shell figured as *Amm. corrugatus* proved a most difficult subject. It has in fact taken me five years to find the truth, even though I was often able to compare Sowerby's original with my own specimens.[2] Three years ago I imagined that it agreed with the young of Vacek's species; but there was a very slight discrepancy in the curvature of the ribs upon the ventral area, and therefore I was not absolutely satisfied. Last summer I obtained some specimens from Dundry; and during a recent visit to the Natural History Museum, I was able to satisfy myself concerning what Sowerby's *corrugatus* really was.

I have already treated of *Ludwigia Murchisonæ*, Sowerby sp., in my Monograph, pt. i., and have nothing further to add thereto; but I will define the other species.

Sonninia corrugata (Sowerby).

1825. *Ammonites corrugatus*, Sowerby, Min. Conch. pl. 451, fig. 3.
1867. ——— *patella*, Waagen, Geogn. Pal. Beitr. (Zone *Amm. Sowerbyi*) pl. 25, fig. 2, 3.

[1] Hitherto unknown (*Haug*). It agrees almost exactly with my fig. 28, pl. A. (Monogr. *Ammonites*, 1889, part iii.), but the inferior lateral lobe is a little larger and is nearer the edge.

[2] I take the opportunity of thanking the officers of the Natural History and Jermyn Street Museums for their kindness and courtesy.

Non *Ludwigia corrugata*, Douvillé.

When young, this species possesses coarse ribs, more or less joined towards the inner margin, and projected forwards on the ventral area; it has a small keel sunk between two furrows; and the preceding whorl is covered about one-half by the next. It soon loses its furrows, obtains a large hollow carina, and at a later date loses its ribs; its envelopment is now two-thirds, quickly decreasing again to one-half at the mouth.

When adult, the species reaches a diameter of 11 inches, is quite smooth, and is then the *Amm. patella*, Waagen, whose name must now give way to Sowerby's. It occurs in the "Ironshot Oolite" of Dundry, Somerset; and I have a large specimen from Sherborne, Dorset. Its horizon is either the *Humphriesianum* or *Sauzei*-zone.

Witchellia læviuscula (Sowerby).

1825. *Ammonites læviusculus*, Sowerby, Min. Conch. pl. 451, fig. 1, 2.
1885. *Harpoceras læviusculum*, Haug, Beitr. Mon. Harpoceras; Neues Jahrbuch für Mineral. etc. Beil.-Bd. iii. pl. xii. fig. 6.

Sowerby's figures of this species are very truthful. They do not, however, show one peculiarity belonging to this species, and in fact to this genus, namely, that when the test is absent, the ventral area carries two deep furrows each side of a carina; when the test is present, the furrows are not observable, while the carina is much raised, and is of the hollow type. The species occurs plentifully at Oborne in the *Sauzei*-zone, and also at Dundry in the Ironshot Oolite, but not so frequently. I have proposed the genus *Witchellia* for species which have the peculiarity of a furrowed core and a hollow carina, compressed sides, coarse irregular ribs with a long ventral projection, and a suture-line which possesses the characteristics of that of *Sonninia*, but is by no means so ornate. The genus begins with the evolute *W. Sutneri* (Branco), and gradually developing ends with the involute W. *læviuscula*.

Hammatoceras amaltheiforme (Vacek).

1886. *Harpoceras amaltheiforme*, Vacek, Oolithe Cap. San. Vigilio. Abh. k. k. geol. Reichsanstalt, Bd. iii. pl. ix. fig. 1 only.

In youth almost exactly similar to *Sonninia corrugata*; but the ribs meet the carina with only an extremely slight forward projection. When adult, the species is entirely different; it is much thicker, and still possesses its coarse ribs. The suture-line is quite different to that of *Sonninia*; the inner lobes crossing the inner area in such an oblique direction—much dependent—are characteristic of the genus *Hammatoceras*.

I possess a whole series showing the evolution of this species from *Hamm. insigne* (Schubler); nor does the development of the genus end here, for a species with a smaller, almost closed, umbilicus is evolved.

This species occurs in the *Concavum*-zone of Bradford Abbas, but is scarce.

IV.—Comparison of the Principal Forms of Dinosauria of Europe and America.[1]

By Professor O. C. Marsh, Ph.D., LL.D., F.G.S.

THE remains of Dinosaurian reptiles are very abundant in the Rocky Mountain region, especially in deposits of Jurassic age, and during the past ten years the author has made extensive collections of these fossils, as a basis for investigating the entire group. The results of this work will be included in several volumes, two of which are now well advanced towards completion, and will soon be published by the United States Geological Survey.

In the study of these reptiles, it was necessary to examine the European forms, and the author has now seen nearly every known specimen of importance. The object of the present paper is to give, in few words, some of the more obvious results of a comparison between these forms and those of America which he has investigated.

With this purpose in view, it will not be necessary to discuss here the classification of the *Dinosauria*, their affinities, or their origin. These topics will be treated fully in the volumes in preparation. For the sake of convenience, however, the ordinal names proposed by the author, and now in general use, will be employed.

Sauropoda.

The great group which the author has called *Sauropoda*, and which is represented in America by at least three well-marked families, appears to be rare in Europe. Nearly all the remains hitherto discovered there have been found in England, and most of them in a fragmentary condition. The skull is represented only by a single fragment of a lower jaw and various isolated teeth, and, although numerous portions of the skeleton are known, in but few cases have characteristic bones of the same individual been secured.

Quite a number of generic names have been proposed for the remains found in England, and several are still in use, but the absence of the skull, and the fact that most of the type specimens pertain to different parts of the skeleton, render it difficult, if not impossible, to determine the forms described.

In the large collections of *Sauropoda* secured by the author in America, which include the remains of more than one hundred individuals, both the skull and skeleton are well represented. On this material, his classification of three families, *Atlantosauridæ*, *Morosauridæ*, and *Diplodocidæ*, has been based. The *Pleurocœlidæ*, also, appear to be distinct, but the remains at present known are less numerous and characteristic than those pertaining to the other divisions of this group.

In examining the European *Sauropoda* with some care, the author was soon impressed by three prominent features in the specimens investigated:—

1. The apparent absence of any characteristic remains of the *Atlantosauridæ*, which embrace the most gigantic of American forms.

[1] Abstract of a paper read before Section C, of the British Association for the Advancement of Science, at the Bath Meeting, Sept. 8th, 1888.

2. The comparative abundance of another family (*Cetiosauridæ*), nearly allied to the *Morosauridæ*, but, as a rule, less specialized.

3. The absence, apparently, of all remains of the *Diplodocidæ*.

A number of isolated teeth and a few vertebræ of one immature individual appeared to be closely related to *Pleurocœlidæ*, but this, for the present, must be left in doubt.

Among the American forms of *Sauropoda*, the skull is now comparatively well known in the principal families and genera. *Brontosaurus*, *Morosaurus*, and *Diplodocus*, typical of their respective families, are each represented by several skulls, some of which are nearly complete, and characteristic portions are known of the skulls of other genera.

The vertebræ, also, and especially the pelvic arch, afford distinctive characters. By the latter alone, the *Atlantosauridæ* and *Morosauridæ* may be readily distinguished. In the absence of the skull, this is a point of importance in a comparison of European with American forms.

In the *Atlantosauridæ*, the ischia are nearly straight, and when in position, extend downward and inward, meeting on the median line by a symphysis of the two ends, as in Crocodiles. In the *Morosauridæ*, the ischia are twisted, and extend inward and backward, with the inner margins alone meeting each other on the median line, the ends being free.[1]

All the ischia of *Sauropoda* known from Europe appear to be of the latter type, although proportionally broader and more massive than those of the corresponding American forms. The ilia and pubes associated with these ischia agree in their main features with those of the American genus *Morosaurus*, so that there can be little doubt that the same general form is represented in both countries.

A striking difference between the *Cetiosauridæ* and the allied American forms is that, in the former, the fore and hind limbs appear to be more nearly of the same length, indicating a more primitive or generalized type. Nearly all the American *Sauropoda*, indeed, show a higher degree of specialization than those of Europe, both in this feature and in some other respects.

The identity of any of the generic forms of European *Sauropoda* with those of America is at present doubtful. In one or two instances, it is impossible, from the remains now known, to separate closely allied forms from the two countries. Portions of one animal from the Wealden, referred by Mantell to *Pelorosaurus* under the name of *P. Becklesii*,[2] are certainly very similar to some of the smaller forms of *Morosaurus*, especially in the proportions of the fore limbs which are unusually short. This fact would distinguish them at once from *Pelorosaurus*, and until the skull and more of the skeleton are known they cannot be separated from *Morosaurus*, and should be known as *Morosaurus Becklesii*. During the examination of this specimen, which is in the collection of its discoverer, Mr. S. H. Beckles, of St. Leonards, England, the author found, attached

[1] Diagrams showing typical ischia in these families and in the *Cetiosauridæ* were exhibited by the author when the paper was read.

[2] Morris's Catalogue of British Fossils, p. 351, 1854.

to the humerus, portions of the osseous dermal covering, the first detected in the *Sauropoda*, and known only in the present specimen.

A dozen or more generic names have been proposed for the European forms of *Sauropoda*, and of these *Cetiosaurus*, Owen, 1841, is the earliest, and must be retained. The remains on which this genus was based are from the Great Oolite, or Lower Jurassic. *Cardiodon*, Owen, 1845,[1] is from nearly the same horizon, and there appears no evidence that the two forms are not identical. *Pelorosaurus*, Mantell, 1850, is from the Wealden, and may be distinct, but, at present, the proof is wanting. *Oplosaurus*, Gervais, 1852, also from the Wealden of England, cannot well be separated from *Pelorosaurus*. *Gigantosaurus*, Seeley, 1869, from the Kimmeridge of the Upper Jurassic, may prove to be different from the above, but the type specimens alone do not indicate it. *Bothriospondylus*, Owen, 1875, is also from the Kimmeridge, and, although the type specimen pertains to a very young, if not fœtal individual, it seems to be distinct, and may be nearly allied to the American genus *Pleurocœlus*. The author failed to find conclusive evidence in the type specimens themselves for the use of the other generic names proposed, namely: *Ornithopsis*, Seeley, 1870, from the Wealden; *Eucamerotus*, Hulke, 1872, Wealden; *Ischyrosaurus* (preoccupied), Hulke, 1874, Kimmeridge; and *Chondrosteosaurus*, Owen, 1876, Wealden.

Æpyosaurus, Gervais, 1852; *Macrurosaurus*, Seeley, 1876; and *Dinodocus*, Owen, 1884, all represent forms from the Cretaceous, but their relations to each other cannot yet be determined.

Discoveries of more nearly perfect specimens may establish the fact that the forms in the different geological horizons are distinct, but so long as the known remains are so isolated and fragmentary, this point must be left in doubt.

The European *Sauropoda* at present known are from deposits more recent than the Lias, and none have been found above the Upper Greensand. In America, this group apparently has representatives in the Trias, was very abundant in the Jurassic, but, so far as now known, did not extend into the Cretaceous.

Stegosauria.

Another group of Dinosaurian reptiles, which the author has called the *Stegosauria*, from the typical American genus *Stegosaurus*, is well represented in European deposits. The remains already discovered are more numerous, and in better preservation, than those of the *Sauropoda*, and the number of distinct generic forms is much larger. The geological range, also, is greater, the oldest forms known being from the Lias, and the latest from the Cretaceous.

These reptiles, although very large, were less gigantic in size than the *Sauropoda*, and were widely different from them in their most important features. Their nearest allies were the *Ornithopoda*, to which they were closely related.

[1] *Cardiodon* dates from 1841 and *Cetiosaurus* also from 1841. See Introduction, Part 2, p. x, of Catalogue Fossil Reptilia, by R. Lydekker (May, 1889).—Edit.

All the known members of the group appear to have had an osseous dermal armour, more or less complete.

One of the best preserved specimens of the *Stegosauria* in Europe was described by Owen, in 1875, as *Omosaurus armatus*, and the type specimen is in the British Museum. It is from the Kimmeridge Clay (Upper Jurassic), of Swindon, England. The skull is wanting, but the more important parts of the skeleton are preserved. Various portions of the skeleton of several other individuals have also been found in England, but the skull and teeth still remain unknown.

A recent examination of these specimens by the author disclosed no characters of sufficient importance to separate them from the genus *Stegosaurus*, and, as the name *Omosaurus* is preoccupied, they should, for the present, at least, be referred to *Stegosaurus*. The discovery of the skull and the dermal armour may not unlikely prove them to be distinct, but the parts now available for comparison do not alone authorize their separation.

The type specimen of *Anthodon serrarius*, Owen, a fragment of a jaw from South Africa, and now in the British Museum, has teeth so very similar to the American forms of *Stegosaurus*, that, judging from these alone, it would naturally be referred to that genus. *Hylæosaurus*, Mantell, from the Wealden, has teeth of the same general type, but most of those referred to it, by Mantell and others, pertain to the *Sauropoda*. This genus, as well as *Polacanthus*, Hulke, from the same formation, *Acanthopholis*, Huxley, from the Cretaceous, and *Scelidosaurus*, Owen, from the Lias, are known from English specimens, but have not yet been found on the Continent. No American forms of these genera have yet been discovered.

An interesting Cretaceous member of this group is the *Struthiosaurus*, Bunzel, 1871, apparently identical with *Danubiosaurus* of the same author, 1871, and *Cratæomus*, Seeley, 1881. It is from the Gosau formation of Austria. Although only fragments of the skeleton and dermal armour are known, some of these are very characteristic. One specimen of the latter, figured by Seeley, and regarded as a dermal plate, bearing a horn-like spine "exactly like the horn-core of an ox,"[1] is very similar in form to some problematical fossils from America, the exact horizon of which is in doubt.[2]

Palæoscincus, Leidy, 1856, from the Cretaceous, and *Priconodon* of the author, 1888, from the Potomac formation, are, perhaps, allied forms of the *Stegosauria*, but, until additional remains are found, their exact affinities cannot be determined. Apparently, the oldest known member of this group in America is the *Dystrophæus*, Cope, 1877, from the Trias of Arizona. In Europe, none have yet been

[1] Quart. Journ. Geol. Soc. of London, vol. xxxvii. pl. xxviii. fig. 4, 1881.

[2] Additional remains secured during the past season prove conclusively that some of these "horn-cores," if not all, were attached to the skull in pairs, and one specimen found in place has since been described by the author as *Ceratops montanus* (Silliman's Journal, vol. xxxvi. p. 477, December, 1888). It is from the Laramie formation of Montana. Others have been found in Colorado and in Wyoming. These are all much larger than the European specimens.

found below the Jurassic. The *Euskelesaurus* of Huxley, 1867, from the Trias of South Africa, is apparently a member of this group.

Ornithopoda.

The great group which the author has called the *Ornithopoda* is well represented in Europe by *Iguanodon* and its allies. The remarkable discoveries in the Wealden of Belgium, of a score or more skeletons of *Iguanodon*, have furnished material for an accurate study of the genus which they represent, and, indirectly, of the family. The genus *Iguanodon*, founded by Mantell in 1824, is now the best known of European forms, and need not here be discussed. *Hypsilophodon*, Huxley, 1870, from the Wealden, is likewise well represented, and its most important characters fully determined. The other genera of this group, among which are *Mochlodon*, Bunzel, 1871, *Vectisaurus*, Hulke, 1879, *Orthomerus*, Seeley, 1888, and *Sphenospondylus*, Seeley, 1883, are described from less perfect material, and further discoveries must decide their distinctive characters.

None of these genera are known from America, but allied forms are not wanting. A distinct family, the *Hadrosauridæ*, is especially abundant in the Cretaceous, and another, the *Camptosauridæ*, includes most of the Jurassic species. The latter are the American representatives of the *Iguanodontidæ*. The nearest allied genera are, apparently, *Iguanodon* and *Camptosaurus* for the larger forms, and *Hypsilophodon* and *Laosaurus* for those of small size. A few isolated teeth from each country suggest that more nearly related forms may at any time be brought to light.

Many generic names have been proposed for members of this group found in America and in Europe, but, in most cases, they are based on fragmentary, detached specimens, which must await future discoveries before they can be assigned to their true place in the order.

As a whole, the European *Ornithopoda* now known seem to be less specialized than those of America, but additional discoveries may modify this opinion. The geological range of this group, so far as known, is essentially the same on each continent, being confined to the Jurassic and Cretaceous. There is some evidence, from footprints, at least, that, in America, the order was represented in the Trias.

Theropoda.

The carnivorous *Dinosauria* have all been included, by the author, in one order, *Theropoda*, although there are two or three suborders quite distinct from each other. This great group is well represented both in Europe and America in the Trias, is especially abundant in the Jurassic, and diminishes in the Cretaceous, at the close of which, it apparently becomes extinct.

The typical genus is *Megalosaurus*, Buckland, 1824, the type of which was the first Dinosaurian reptile described. Although its remains are comparatively abundant in Europe, they have been found only in a fragmentary condition, and many important points in the structure of the skull and skeleton are still in doubt.

The oldest representatives of this group in Europe are *Thecodontosaurus*, Riley and Stutchbury, 1836, and *Plateosaurus*, von Meyer, 1837, both from the Trias. The former genus is from the lower horizon, near Bristol, England; the latter, from the Keuper of Germany. *Zanclodon*, Plieninger, 1846, is from the same horizon as *Plateosaurus*, and appears to be the same thing. *Massospondylus*, Owen, 1854, from the Trias of South Africa, is apparently a form allied to *Thecodontosaurus*. The nearest American genus is *Anchisaurus*, two species of which are known from the Connecticut River sandstone.

The most interesting member of the *Theropoda* known in Europe is the diminutive specimen described by Wagner, in 1861, as *Compsognathus longipes*. The type specimen, the only one known, is from the lithographic slates of Solenhofen, Bavaria, and is now preserved in the Museum in Munich. Fortunately, the skull and nearly all the skeleton are preserved, and as it has been studied by many anatomists, its more important characters have been made out. It is regarded as representing a distinct suborder, and no nearly related forms are known in Europe. Its nearest ally is probably the specimen from Colorado, described by the author, in 1881, as *Hallopus victor*. This animal was about the same size as *Compsognathus*, and resembles it in some important features. It is probably from nearly the same geological horizon, but may be somewhat older. Each of these specimens appears to be unique, and until a careful comparison of the two is made, their relations to each other can only be conjectured.

The American representative of *Megalosaurus* is apparently *Allosaurus*, a genus established by the author, in 1877. The type specimen is from Colorado, from a higher horizon in the Jurassic than that of *Megalosaurus*. Nearly every part of the skeleton of this genus is now known, and the more important portions have been described and figured by the author. *Creosaurus*, also from the Jurassic, is an allied form, and *Dryptosaurus*, from the Cretaceous, is, perhaps, also closely related. A very distinct form in the Jurassic is *Labrosaurus*, described by the author, in 1879. It is known from detached specimens only, but these, especially the jaws, edentulous in front, show it to represent a distinct family.

The most perfectly known of American *Theropoda*, and by far the most interesting, is the genus *Ceratosaurus*, founded by the author, in 1884. This is the representative of a very peculiar family, which differs in some important respects from all other known Dinosaurs. The skull and nearly all the various parts of the skeleton are known. When found, they were entire, and in the position in which the animal died. The skull and some of the more interesting parts of the skeleton have been figured by the author, and all will soon be fully described.

The skull bears a large elevated horn-core on the median line of the nasals. The cervical vertebræ differ in type from those of any other known reptiles, having the centra plano-concave. All behind the axis have the anterior end of each centrum perfectly flat, while

the posterior end is deeply cupped. This genus, moreover, differs from all known Dinosaurs in having the elements of the pelvis (ilium, pubis, and ischium) coössified, as in all existing birds. The metatarsals, also, are firmly united, as in birds. No representatives of the *Ceratosauridæ* are known in Europe.

In conclusion, it may safely be said that the four great groups of *Dinosauria* are each well represented both in Europe and America. Some of the families, also, of each order have representatives in the two regions, and future discoveries will doubtless prove that others occur in both.

No genera common to the two continents are known with certainty, although a few are so closely allied, that they cannot be distinguished from each other by the fragmentary specimens that now represent them. It must be remembered that the great majority of genera have been named from portions of skeletons, of which the skull was unknown, and until the latter is found, and definitely associated with the remains described, the characters and affinities of the genus can be only a matter of conjecture, more or less definite, in proportion to the perfection of the type specimens.

From Asia and Africa, also, a few remains of Dinosaurs have been described, and the latter continent promises to yield many interesting forms. Characteristic specimens, representing two genera, one apparently belonging to the *Stegosauria*, and one to the *Theropoda*, are already known from South Africa, from the region so rich in other extinct Reptilia.

From Australia, no *Dinosauria* have as yet been recorded, but they will undoubtedly be found there, as this great group of Reptiles were the dominant land animals of the earth, during all Mesozoic time.

V.—Second Note on *Stenotheca*.

By G. F. Matthew, M.A., F.R.S., Canada.

SOME three years ago the writer communicated to this Magazine a "Note on the Genus *Stenotheca*" of Hicks,[1] stating that from the appearance of the species, which on this (western) side of the Atlantic had been referred to it, it did not seem to belong to the Pteropoda, but more probably to the Gasteropoda. I also stated that there were two distinct types of shells which had been referred to *Stenotheca*, one of which by its internal muscular scar and position of the umbo might be compared to *Parmophorus*, etc.; while the other, represented by a number of minute species, appeared to correspond to the original *Stenotheca* of Dr. Hicks.

Collections of these smaller fossils, made subsequently to 1885, led the writer to think that they were the shells of Crustaceans, and he applied to Dr. Hicks for an authentic example of his *Stenotheca*; this Dr. Hicks kindly sent, and the example proved to be congeneric with the smaller shells of the St. John Group which had been referred to *Stenotheca*, and which had been found to be those of Crustaceans.

[1] See Geol. Mag. Decade III. Vol. II. 1885, p. 425.

But the larger shells, which by Billings, Walcott, and the writer have been referred to *Stenotheca*, are Gasteropods allied to *Metoptoma*. They are not, however, of this genus, which has been described as having a truncated apex, whereas the beak of the Cambrian shells is arched and acuminate at the apex.

The minute shells, of which *S. concentrica* is the type, and which alone are properly of the genus *Stenotheca*, show, when magnified, a chasing of waving or chevron lines visible both on the outside and inside of the crust, and these lines *are much more distinct on the inside.* There is no suture along the back, the folded carapace having been irregularly cracked where the sides have been crushed together in the shale. No nuchal piece has been observed, so it appears to have had a minute carapace of one piece only. These fossils are not very plentiful, but occasionally they are found in considerable numbers on layers of the fine dark shales which are equivalent to the Menevian shales of St. David's in Wales.

St. John, N.B., Canada.

VI.—Glaciation of Eastern Canada.

By Robert Chalmers, Esq.,
Of the Canadian Geological Survey.

A PAPER on the Glaciation of Eastern Canada by the writer will shortly appear in the Canadian *Record of Science*, Montreal. It is intended to be a condensed statement of the principal facts hitherto collected on this interesting subject, with references to the reports and publications in which details are given. The following is an abstract which I send to the Geological Magazine in advance. The subject is regarded as an important one, and has occupied the attention of geologists for many years, as Eastern Canada is the battle ground, so to speak, of the advocates of the rival theories of continental glaciation and floating ice. The results thus far obtained from a somewhat careful study of its glacial phenomena, however, point to conclusions which are at variance with those held by extreme glacialists, and show that the theory of local glaciers upon the more elevated portions of the country and icebergs or floating ice striating the lower coastal areas during the Post-Tertiary submergence of these, as maintained by Sir William Dawson, will serve to explain all the observed phenomena. The term 'local glacier' I define as an ice-sheet limited in extent, that is, confined to one valley or hydrographic basin, whether large or small, and influenced in its movements by local topographic features, such as mountains, water-sheds, hills, or the valleys of the larger rivers. The data have been collected chiefly by the staff of the Geological Survey; but Sir William Dawson, who has long studied this region, and others have done much valuable work in glacial geology here.

In reference to the origin and movements of local glaciers, it may be stated, that the main facts pertaining to each centre of dispersion, when correlated, show that these glaciers were independent bodies

which had large gathering grounds upon the higher parts of the country where snow fields and *névé*-ice must have existed. Whenever motion began this snow or *névé*-ice became converted into glacier-ice. Upon areas where they never underwent change into ice no striation of the rocks took place. In their movements the glaciers, generally speaking, followed the slopes of the land or the present drainage channels. Some of them seem to have been quite large, and those from adjacent drainage areas may have coalesced on the lower grounds and become confluent. At all events, the slopes and coastal tracts are usually more glaciated than the interior and higher grounds.

In Nova Scotia there was a shedding of ice from the Cobequid Mountains northward and southward, and the South Mountain appears also to have sent glaciers down its slopes, on either side. Sir William Dawson, Dr. Honeyman, Mr. H. Fletcher, Dr. R. W. Ells, and others have made numerous observations showing many divergent courses of striæ, which are explicable only on the theory of local glaciers and icebergs.

The main water-shed of New Brunswick, which traverses the province from north-west to south-east, sent off glaciers in nearly opposite directions, or north-eastward towards the Baie des Chaleurs and Gulf of St. Lawrence on the northern slope, and south-eastward towards the Bay of Fundy on the southern slope. This is abundantly proved by data collected by the writer and others.[1]

Considerable areas in the interior of this province, where centres of dispersion for local glaciers existed, are unglaciated, no ice-action whatever nor Boulder-clay being seen, and the loose materials consisting largely of rock debris *in situ*. These were probably snow-fields and gathering grounds for the ice during the Glacial period. The glaciers on the southern slope appear to have been much larger than on the northern. But even upon the former they had numerous local and divergent movements, as the evidence shows.

The Shickshock or Notre Dame Mountains in South-Eastern Quebec and their continuation south-westward had also large gathering grounds for snow and ice on their summits and shed glaciers south-eastward into the Baie des Chaleurs and the valleys of the Restigouche and St. John rivers, and north-westward into the St. Lawrence valley, the estuarine portion of which must then have been open to receive them.[2] The valleys of tributary rivers and the subordinate ridges and hills caused, however, many local deflections in the ice-currents.

The glacial phenomena of the Archæan area north of the St. Lawrence and great lakes have also been investigated to some extent. The general parallelism of the Laurentian slope, north of the St. Lawrence, to that of the Notre Dame Range, caused the striæ observed on it to have nearly the same course as those on both slopes of the latter, the ice flowing down the slopes at about right

[1] Annual Report, Geol. Surv. Canada, 1885, vol. i. part GG.
[2] Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

angles to the main axes of the mountains.[1] This fact has been made use of to support the theory of a massive ice-sheet moving from the Laurentides across the St. Lawrence valley over the summits of the Appalachians and down the New England slope to the Atlantic. But as will be seen the evidence at hand does not support this view. The Archæan area has, however, sent sheets of ice down its slopes in all directions around its circumference. In the central part, on the east side of Hudson Bay, they moved directly westward into its basin. In Hudson Strait, according to Bell, the ice had a north-eastward and eastward flow. Whether the whole Archæan area was covered by glaciers flowing outwardly from the centre towards the circumference, or with snow fields forming the *névé* of local glaciers, as seems more probable, is a question to be decided by future investigation. Areas of unglaciated rock surface, doubtless, occur there as well as upon other elevated portions of Eastern Canada where decomposed rock lies undisturbed except from subaerial action.

The extent and thickness of the glaciers cannot as yet be satisfactorily determined; but they seem to have been largest on the southern slopes of the Appalachians and Laurentides. The cause of this is not evident; but as regards those of the first-mentioned mountains, which are in a part of the country with which the writer is most familiar, it may be owing in some measure at least to the difference in the steepness of the slopes on either side of it. The south-east slope is long, much broken, and has numerous comparatively level areas upon it. As the rate of motion would be slower on this slope, the ice would necessarily accumulate in larger sheets in depressions and on the level tracts. On the shorter and steeper slope of the St. Lawrence the motion of the ice would be more rapid, and it would more readily debouch into the estuary or sea.

Evidences of the action of icebergs or floating ice are found in the St. Lawrence valley and on the Baie des Chaleurs coast, also in a number of other places around the shores of the Gulf of St. Lawrence. So far as the writer has observed, they are met with only on ledges below the 200 to 350 feet contour-line above sea-level. Floating ice seems to have played an important part in transporting boulders over the submerged areas.

The views here briefly outlined will doubtless undergo some modification, as this region, especially when that part of it known as the great Archæan area, comes to be studied in greater detail. I think, however, the main conclusions herein advanced will stand.

Newfoundland, although not forming part of Canada, is geographically connected with it, and its glacial phenomena may therefore be referred to in this connection. The late Alex. Murray, C.M.G., Director of the Geological Survey for many years, states that its surface is everywhere glaciated.[2] He held the theory of a continental

[1] Geology of Canada, 1863, pp. 890–92; Notes on the Post-Pliocene Geology of Canada, 'Canadian Naturalist,' 1872; Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

[2] Transactions of the Roy. Soc. of Canada, 1882, sec. iv., paper on the Glaciation of Newfoundland.

ice-sheet, however; but his facts show that the striæ are quite divergent, following depressions and valleys in different directions. It seems probable, therefore, that here, as in Eastern Canada, local glaciers produce the chief striation observed, as pointed out by the late Captain Kerr, R.N.[1] But from its insular position, and lying as it does in the track of the Arctic currents, the coast areas must have been intensely eroded from icebergs and floating ice.

Ottawa, Canada.

VII.—On the Occurrence of Ottrelite in the Phyllites of North Cornwall.

By W. Maynard Hutchings, Esq.

THE mineral ottrelite, which has received so much attention elsewhere, especially in the Ardennes, and which is of considerable interest in connection with the metamorphism of certain rocks, has not, up to now, ever been reported as occurring anywhere in Great Britain.

I am able to state that I have discovered it in considerable amount in a certain roofing-slate of North Cornwall.

The slate in question is one of a series of specimens of the phyllites of the district collected by me during two successive summer holidays at Tintagel. This series includes most of the roofing-slates of the neighbouring quarries, together with many other slates and slaty rocks, which, while closely of the same general nature as the roofing-slates, differ from them in not having sufficient hardness and fissility to render them fit for quarrying. I have long studied some of these rocks under the microscope, and latterly have been supplied, by the kindness of Mr. Teall, with material from the Ardennes for comparison, as well as with the principal original literature concerning them from the pens of Rénard, Renard and Vallée-Poussin, and Gosselet. The resemblance in many essential points between some of the Cornish rocks and some of the occurrences described by these petrologists, is very interesting, and leads me to think that some account of the Cornish ottrelite-slate and its neighbours may be of some little value.

I will first describe somewhat in detail the slate in which the ottrelite occurs, and the characteristics here shown by that mineral and by which it was identified. Owing to the close general resemblance between all the phyllitic rocks of the district, it will afterwards be a very simple matter to point out the few details of variation.

The ottrelite-slate in question is quarried in the cliffs near to Tintagel Church, the quarry being owned and worked by the Reverend Prebendary Kinsman, Vicar of Tintagel, to whom I am much indebted for the trouble he has kindly taken in forwarding more specimens, and in giving me information since my personal visit to the place.

[1] *Ibid.* p. 68.

The slate is of a greenish-grey colour, close and hard in texture, with a silky lustre rather inclining to resinous in the best kinds. Moderately thin flakes of it are translucent on the edges. It splits easily into very thin sheets, which are strong and sonorous; and appears to be a really first-class roofing-material, equal in every way to the best products of the celebrated quarries at Old Delabole, a few miles inland.

It is fossiliferous, apparently as much so as the Delabole slate so well known in that respect, and Mr. Kinsman informs me that the fossils from the two localities are identical in nature.

There are two quarries at Tintagel very near together, but it is only in the slates from the "New Quarry," nearest to the church, that I have found ottrelite.

Macroscopically, nothing of its mineralogical composition can be made out except that it is more or less speckled over with pyrites, and stained here and there with ferric oxide due to the oxidation of that mineral.

When very thin sections of it are examined under the microscope, it is seen that the main constituent is sericitic mica. By far the greater part of this sericite lies flat in the plane of cleavage of the slate, the flakes overlapping and felted together to an aggregate which, between crossed Nicols, forms a dimly-polarizing, blue-grey base in which the other minerals are set. A great many flakes of sericite, however, are not arranged parallel to the cleavage, but lie in all directions, polarizing in brilliant colours.

The two other principal constituents of the rock are ilmenite and ottrelite;—it might be best described as being a sericite-ottrelite-ilmenite phyllite.

The ottrelite is very abundant. It occurs entirely as quite irregular and indefinitely-bounded, mostly more or less ragged flakes, dispersed pretty uniformly throughout the rock.

The arrangement of the flakes bears no definite relationship to the plane of cleavage of the slate; they lie flat in this plane, vertical to it and at every intermediate degree of inclination. The size is very variable, but as a whole it is very much less than in the well-known rocks of Ottrez, Serpont, and other places in the Ardennes. The largest flakes are usually oblong in shape, the long diameter seldom exceeding $\frac{1}{20}$ inch, and reaching this only in the minority of cases. A usual average, especially in the more rounded forms, is close around $\frac{1}{100}$ inch; but there is ample evidence that the mineral has been much torn and broken up since its formation, and lesser flakes exist down to exceedingly small fragments. The thickness is as variable as the other dimensions. It does not exceed $\frac{1}{1000}$ inch, and most of the flakes are very much less, down to $\frac{1}{3000}$ inch, which seems to be the thickness of a large proportion of the fairly thin ones measured.

The characteristic secondary cleavages, intersecting on the basal plane, are largely developed, though in many flakes they are considerably distorted, and are also frequently much masked by irregular cracks and ruptures, these effects being due to the stress the

mineral has undergone during rock-movements. These cleavages are best studied on flakes isolated from the rock and separately mounted. The two most important of these secondary cleavages intersect on the basal plane at an angle of 120° or an approximation to it. Many measurements give that angle exactly, while many more vary but little from it, though some diverge more markedly. Rosenbusch states that there is a third cleavage, less well developed, bisecting the obtuse angle of the other two. Cracks answering to this description may be seen in some flakes of the Cornish mineral, but they are few and not very marked. The French writers speak of a cleavage approximately vertical to one of those intersecting at 120°, and many cracks corresponding to this may also be seen in the mineral now under consideration. But it really does not seem possible to say that either is really a definite cleavage, or to be in any way certain concerning any third line of cleavage observable on the basal plane. The cleavage-cracks are nearly all quite vertical to the basal plane, and are seen on the lath-shaped cross-sections of the flakes as lines nearly always at right angles to the lateral boundaries, obliquity being rare and very slight.

Most of the ottrelite flakes are intergrown with crystals of white mica, so that nearly all the narrow lath-shaped sections are seen to be united with one, or usually with two, flakes of the mica, one on each side, the individuals lying perfectly parallel, and in cases where the ottrelite is so cut that it extinguishes parallel to its length, the whole combination extinguishes together. The petrologists who have described the rocks of the Ardennes do not appear to have observed a similar intergrowth of ottrelite and mica.

Gosselet considers (Etudes sur l'Origine de l'Ottrélite, Annales de la Société géologique du Nord, tome xv. p. 85) that in the rocks he studied the ottrelite was formed at a time after the phyllites were already fully developed as such. This appears to be equally the case in these Cornish slates, and it is quite evident on observation of structure and arrangement, that the white mica with which the ottrelite is intergrown was formed at the same time. It is in larger and much more definitely-bounded individuals than the main sericite of the rock. There are also crystals, apparently of the same generation, but not intergrown with ottrelite. The dimensions of some of these average about $\frac{1}{150}$ inch in length by half that width, in sections vertical to the base.

This intergrowth with mica renders much of the optic examination of the ottrelite impossible in the slate direct. By pulverizing some of the rock moderately fine, a number of the thicker flakes may easily be detached from the mica, and are then easily separated out by means of a Sonstadt solution of sp.g. of about 3, most of the thinner flakes remaining suspended attached to mica. Material so separated is suited for optic examination, and, as above stated, for study of the cleavages, much of it being in sharply-bounded cleavage-fragments.

In colour the Cornish mineral is more inclined to blue than the ottrelite of Ottrez. The characteristic pleochroism is strongly developed. The scheme is a=yellowish green, β=blue, γ=pale greenish yellow.

Examined between crossed Nicols a large proportion of the lath-shaped cross-sections are seen to be twinned, but this twinning does not seem to be as pronounced as in some of the other occurrences of the mineral, there being mostly only two lamellæ even in the thicker bits, and many flakes being quite untwinned.

Many of these sections extinguish quite parallel to their length, but the greater number show an angle, which reaches as high as 20 degrees and over in some cases, though about 12 degrees is a more usual figure.

The examination of selected, sufficiently thick, and untwinned fragments from the isolated material in convergent polarized light shows the emergence of a positive bisectrix on the principal cleavage-face of the mineral. The angle of optic axes is rather large. The optic-axial plain bisects the obtuse angle formed by the two best-developed secondary cleavages.

As usual, the ottrelite is rich in inclosures, but is very much less crowded than in most other occurrences. The principal mineral inclosed is rutile, in perfectly formed crystals for the most part, many being twinned both as "knees" and "hearts." The largest crystals measure $\frac{1}{2000}$ inch, and they pass from this into the merest specks through all intermediate sizes. Other included matter is very small in amount, and mostly quite indeterminable in nature, with the exception of white mica which is frequent, and which is in many cases seen to occupy cracks and seams in the ottrelite. Many bits are also full of cavities of all shapes and sizes.

Gosselet states that he was able to observe, around the individuals of ottrelite, zones which were very much less rich in microlites than the rest of the rock. This is not the case in the Tintagel slate. The whole rock is very rich in minute rutile crystals; but though the ottrelite contains them in far greater abundance than does the sericite, there is no sign that it has impoverished the space just around it.

No quantitative analysis has been made of the isolated material, but it has been tested as to its resistance to acids, and has been qualitatively analyzed, the results of these examinations confirming the optical and other evidence that the mineral is ottrelite. Specimens of the rock have been submitted to authorities in this country and on the continent, who also recognize the mineral as ottrelite.

No doubt it will be found in other similar slates when search is made, as well as at Tintagel.

The ilmenite of this rock is well worthy of remark. It is present in considerable amount in nearly all the phyllites examined, but is perhaps more abundant in this ottrelite-slate than in any other. It is pretty evenly diffused in little flakes and tablets. Some of it is in the form of the thinnest "micaceous ilmenite," perfectly transparent, with rich brown colour, and there is every gradation of thickness and translucency up to tablets which are perfectly opaque. The thinner and medium-thick flakes are all more or less ragged, but many of the thicker tablets show more

definite boundaries, and indications of crystal faces at the edges. The average diameter of the flakes is about $\frac{1}{500}$ inch, and the thickness of the opaque ones ranges between $\frac{1}{2000}$ and $\frac{1}{4000}$ inch.

Like the ottrelite, the ilmenite lies in all directions with regard to the cleavage of the slate, but a considerable majority of the flakes are approximately parallel to it.

A large part of this ilmenite is reticulated, in varying degree, with sagenitic rutile. Among the thinner transparent flakes all degrees may be seen, from such as show a wholly unbroken brown colour, to others which are so finely meshed with delicate interlacing lines of rutile, that only a high power suffices to display the structure; and there are, finally, bits of sagenite in the network of which no trace of ilmenite is seen. Thicker plates of ilmenite also often show a development of sagenite, while many show only a line here and there. Such of them as are still thin enough to be at all translucent frequently show indications, in strong light and under high power, that a little thinning would expose complete reticulations.

Rénard has devoted considerable study to similar occurrences of ilmenite in rocks of the Ardennes. In a paper published in 1884 (Recherches sur la Composition et la Structure des Phyllades Ardennais, Bulletin du Musée Royal de l'histoire naturelle de Belgique, tome iii. pp. 231–268) he described in detail, and figures the "phyllade à ilménite des Forges de la Commune." The occurrence in this case is clearly of the same nature as in the Cornish slate, this being borne out by sections of the Belgian rock which I have examined; the difference being that in the latter the flakes are a good deal larger, while the amount present is very much less, as is also the proportion of it which is transparent or in which sagenite is developed. Rénard was at great pains to isolate some of the mineral and prove chemically that it is ilmenite. In the Cornish rock, in face of the large amount of transparent brown flakes, such chemical proof would scarcely be called for; but it is all the better that Rénard carried it out, inasmuch as it does not seem practicable to isolate the much smaller flakes and tablets of the Tintagel slate.

No better material could be desired than these North Cornish phyllites for the study of these highly interesting microscopic sagenites and their combinations with ilmenite; and in view of the large amount of very thin, thoroughly transparent flakes so combined, I have been in hopes that by careful study of them some light might be thrown on the question as to how the combination ought to be regarded; whether the sagenite is a secondary product resulting from the decomposition of the ilmenite; whether the two have been originally formed together as now seen; or whether, in any cases, the intervening ilmenite has resulted from an alteration of the rutile, the occurrence of alterations of rutile into ilmenite having been demonstrated by V. Lasaulx.

The first of these alternatives is that which most readily suggests itself on first examination of the minerals; and it might seem to derive some support from Cathrein's observation that ilmenite dissolved in acid frequently leaves a residue of extremely minute

needles of rutile. In the course of an investigation of the ilmenite and leucoxene of certain schists from Wildschönau in the Tyrol (Zeitschrift für Krystallographie u. Mineralogie, Band 6, pp. 244–256) he found that ilmenite, which was perfectly homogeneous and opaque under the microscope, left a considerable amount of such residue on solution. By using hydrochloric acid for this purpose, he was able to detect combinations of the most delicate needles of rutile in networks and "gratings" of sagenite.

He does not say whether he himself came to any conclusion as to the primary or secondary nature of these interpositions, which appear to correspond with what is so well seen in the thin ilmenite flakes of the Cornish slate; neither does Rénard, so far as I am aware, express any opinion on this point, nor do I know of any other authority who has done so.

After long and careful examination of these forms I do not find it possible to say that there is much evidence one way or other, but consider that on the whole it appears most probable that it is a case of original inter-crystallization.

The study, under high powers, of the thinnest, most transparent flakes in every degree of reticulation, seems to show that in all cases the rutile of the sagenite is so very sharply marked off from the ilmenite that the idea of a chemical change going on between the two is not easily entertained.

The whole question as to the mode of origin of these ilmenite flakes is one of great interest. It seems clear, from the manner of occurrence in the rock, that like the ottrelite they were produced at some period posterior to the formation of the sericite-phyllite as such, and there is much evidence that they also have been much torn and broken up at a still later period.

Calcite is present in this slate in noticeable amount in the form of grains and small patches irregularly diffused all through it.

There are a few small patches of pale chlorite, of which it is to be remarked that they are quite free from the microlites of rutile, so abundant in the rest of the rock. Tourmaline in perfect hemihedral crystals is well represented, these crystals measuring in most cases $\frac{1}{300}$ inch in length. They appear all to lie with their long axes parallel to the plane of cleavage of the slate.

This slate is so completely metamorphosed that nothing whatever can be detected which could be referred to the original clastic material out of which it has been formed, except a few crystals and rounded grains of zircon.

Roofing-slates from other quarries of the district all resemble that just described in general structure and composition, though, with the exception of the fundamental basis of sericite, the amounts of the various minerals present vary a good deal. Thus ilmenite is much more abundant in some than in others, and in some cases does not show any sagenite. The latter is present in numerous and fine examples, however, in the Delabole slates.

Garnets are plentiful in some slates, as at Delabole.

The other phyllites, not fit for roofing-slates, show rather more

variety of composition. Chlorite is much more abundant in some of them. Ilmenite is almost universal, and in many cases is as abundant and as full of sagenite as is the ottrelite-slate. Garnet is very abundant in some cases, and most of all in specimens taken from near the contact with one or other of the igneous rocks described in a recent paper.

This garnet is all colourless, or very nearly so. It is in the form of very small irregular grains with only here and there a solitary case of any crystal-form.

Tourmaline is much increased in amount near the contacts, and is in some cases the main constituent after the sericite.

Rutile is present in large amount in all the phyllites of the district, as minute crystals, and, in some cases, also in large grains and tablets.

In none of the many specimens examined by me, have I come across any ottrelite, except in the one case described. It is hardly likely that it is limited to the one particular quarry, but I have not been so fortunate as to find it anywhere else.

There are several beds of black, shaly rock in among the sericite phyllites at various points. They are almost wholly siliceous in nature, very fine-grained quartzites cemented and veined with infiltrated silica and permeated through and through by fine carbonaceous matter. These rocks contain but little of any other minerals, and do not present any special interest.

VIII.—On the Secular Straining of the Earth. I.[1]

By Charles Davison, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

As early as the times of Descartes (1668) and Newton (1681), the "settling and shrinking of the whole globe after the upper regions or surface began to be hard,"[2] was held a sufficient cause for the formation of mountain-chains. Following the growth of our knowledge of mountain-structure, the contraction theory has been rediscovered several times in the present century. It has been worked out in great detail by Élie de Beaumont, Prevost, Delabeche and others; but, above all, by J. D. Dana, the real founder of the theory, in an admirable series of papers extending over the last forty-two years.

[1] Read before the Birmingham Philosophical Society on Feb. 14, 1889. In this paper I have attempted to give an account of part of a paper "On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling, etc.," read before the Royal Society on May 5, 1887 (Phil. Trans. 1887, A. pp. 231-242). The reasoning in ch. xi. of Mr. T. Mellard Reade's work on "The Origin of Mountain Ranges" (1886) shows that he had previously perceived the existence of a surface of zero-strain in the earth's crust, separating an outer region of crushing from an inner region of stretching. In his well-known paper, "On the Formation of Alpine Valleys and Alpine Lakes" (Phil. Mag., Feb. 1863, 4th ser. vol. xxv. p. 97), Mr. John Ball arrived at the conclusion that folding by lateral pressure diminishes as the depth from the surface of the earth increases, until it becomes insensible.

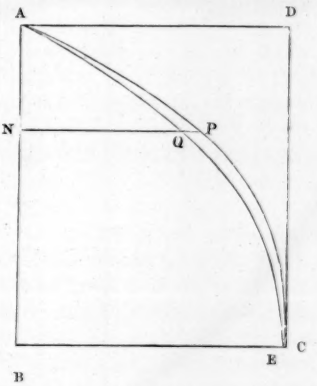
[2] Brewster's "Memoirs of Sir Isaac Newton," vol. ii. Appendix 4; Nature, vol. xxxviii. p. 30.

Leaving its details out of account, the fundamental idea in the contraction theory may be stated as follows: The whole earth was originally at a high temperature throughout, its present distribution of temperature being the result of cooling since the initial epoch. The surface of the earth has now practically ceased to cool, and the interior at and below a depth of two or three hundred miles has not yet begun sensibly to lose its heat. The intermediate layer in cooling contracts, and the outermost crust, being deprived of its support, is crushed and folded by the tremendous pressures thus brought into action. The ridges and wrinkles, into which the crust is thrown, constitute our mountain-chains.

It is curious that, until recently, attention has been wholly concentrated on the behaviour of the outer crust with respect to the cooling layer beneath it, and that the behaviour of the cooling layer itself with respect to the uncooled nucleus within has passed unnoticed. Taking this latter relation into account, however, it will be found that new light is thrown upon several points of the theory, and especially on the comparatively superficial nature of the mountain-making forces.

I shall assume in this paper the truth of the doctrine, which recent researches agree in indicating with a high degree of probability, that the earth is practically a solid body; also of Sir W. Thomson's celebrated investigation on the secular cooling of the earth. Further, in order to simplify the problem, I shall suppose the earth to be a sphere and its surface perfectly smooth.

Taking the initial temperature of the earth at 7000° F., and the average rate near the surface at which the temperature increases with the depth at 1° F. for every 51 feet, Sir W. Thomson shows that the date at which the earth solidified cannot have been less than 20 million, nor more than 400 million, years ago, that it was probably not far from 100 million years ago. In his well-known paper, he gives a curve which represents the temperature at different depths, and which is reproduced in the accompanying figure. The depths from the surface are represented by lengths measured from A along the line AB. The temperature at the depth AN is represented by the length of the line NP drawn at right angles to AB. If lines like NP be drawn from every point in AB, and if each line be made proportional in length to the temperature at the corresponding depth, the other ends will all lie on the curve APC. At the depth represented by AB, about 150 miles, the temperature is very nearly the same as it must be in the entire mass below.



At a subsequent date, every point, through cooling, is at a lower

temperature. The state of temperature may then on the same scale be represented by the curve AQE. The temperature corresponding to the depth AN is now represented by the line NQ instead of NP, so that the amount of heat lost in the interval is represented by the length of the line QP. If we now suppose the line NQP to start from AD and to move downwards, keeping parallel to itself, the part QP, at first zero increases for a certain distance, until it becomes a maximum, and then it decreases until the line NQP reaches the position BEC, where it is practically again zero. Since the rate of cooling is proportional to the amount of heat lost in a given time, it follows that this rate is zero at the surface, that it increases as the depth from the surface of the earth increases, until it is a maximum, after which it decreases, becoming insensible at a depth of two or three hundred miles. If the time since the earth solidified be 100 million years, Prof. G. H. Darwin has shown[1] that the depth at which the rate of cooling is greatest is about 53 miles. He has shown also that this depth increases in proportion to the square root of the time, that is, at four hundred million years the depth will be twice as great as this, three times as great at nine hundred million years, and so on. At the initial epoch, it coincided with the surface of the earth.

If a sphere, having the same centre as the earth, pass through the point at which the rate of cooling ceases to be sensible, it will include within it the whole mass of the earth which has not yet begun to lose its heat, the "uncooled nucleus," as it has been called above. The rest of the earth, constituting the "cooling layer," may be supposed to be divided up into a very great number of very thin shells by spherical surfaces all having the same centre as the earth. Each shell must be imagined so thin that the rate of cooling varies by an infinitely small amount between the inner and outer surfaces of the shell.

Let us now consider the consequences of the method of cooling described above; and, first, in the lowest shell of the cooling layer, that next to, and surrounding, the uncooled nucleus. In a given time, this shell loses a definite, though small, amount of heat, in consequence of which it must contract in volume. If the shell were isolated, it would also contract in radius, by an amount proportional to the loss of heat. But this is prevented by the presence of the nucleus within. The contraction can therefore be accomplished only by the shell stretching over the nucleus, at the same time diminishing in thickness.

The next succeeding shell is stretched in a similar manner. If the loss of heat were the same as in the first shell, both shells would be stretched by very nearly the same amount. But it loses more heat in the same time, for the rate of cooling at first increases from the nucleus outwards. The second shell is therefore stretched more than the first. In like manner, the third is stretched more than the second; and this is the case with every shell to very nearly as far as the surface where the rate of cooling is greatest.

[1] Nature, vol. xix. p. 313.

Above this surface a change takes place. In this part of the earth's crust each shell in a given time loses less heat than the shell below it, and consequently undergoes less stretching. The stretching thus decreases gradually and continuously towards the surface of the earth; and it may be shown that at a certain point it vanishes altogether.

To do this, we must consider the shells close to the surface of the earth. The outermost shell of all is not losing any heat. The layer between it and the nucleus, by cooling and contracting, is diminished in thickness, and tends to leave the shell unsupported. But, immediately this takes place, enormous lateral pressures are developed by the attraction of all the earth's mass within; and the outermost shell is crushed and wrinkled until it rests completely on the mass below. In the same way, the shell next below the outermost is crushed and folded, but not to so great an extent, for it does lose a certain small amount of heat, and the contraction due to this brings it a little nearer the mass on which it is obliged to rest. In the shell below this, the loss of heat is still greater (for the rate of cooling increases from the surface downwards), and the amount of folding still less, and so on. Thus the folding and crushing of the shells gradually and continuously diminish as the depth from the surface increases.

We have now the following state of things. From the surface of greatest rate of cooling, stretching gradually diminishes outwards. From the surface of the earth, crushing and folding gradually diminish inwards. At some point between the surface of the earth and the surface of greatest rate of cooling, there must be a shell which is being neither stretched nor crushed. We may call it therefore the "surface of zero-strain."

This surface plays an important part in the physical history of the earth. If the contraction theory be true, our loftiest mountain-ranges must be formed principally, perhaps entirely, of the material in the comparatively thin layer of rock outside it. Our earthquakes and volcanic eruptions probably originate at points above the surface of zero-strain.

It would therefore be an interesting and important problem to determine, if we could, the depth of the surface of zero-strain; but, in the present state of our knowledge, it is impossible to do this accurately. Assuming, however, that the coefficient of dilatation and the rate of conductivity are the same at all temperatures, that the surface of the earth is a sphere, and that the stretching or folding of any shell is uniform all over that shell, I found, by an approximate method which it is hardly necessary to describe, that the surface of zero-strain was, or more probably will be, at a depth of five miles after an interval of 174,240,000 years since the earth solidified.[1] This depth, on account of the method of calculation employed, is too great by a fraction of a mile, but we shall probably be well within the limits of error if we put it at between four and five miles.

[1] This period was adopted in order to simplify the calculations, and is well within the limits given by Sir W. Thomson.

At the same time and on the same assumptions, the depth of the surface at which stretching is greatest would be about 72 miles, this surface being less than a mile below the surface of greatest rate of cooling.

We may sum up the results obtained for this period as follows, assuming the surface of the earth to be smooth and spherical: Folding by lateral pressure is greatest at the surface. It diminishes as the depth increases until, at a depth between four and five miles, it vanishes. Below this depth, folding by lateral pressure gives place to stretching by lateral tension, and the stretching increases as the depth increases until it is a maximum at a depth of about 72 miles. Below this, again, the stretching begins to decrease, and it continues decreasing, until it practically vanishes at a depth of about 200 miles.

If the contraction theory be true, the most important evidence which the surface of zero-strain gives us is that relating to the extremely superficial nature of the forces which produce our mountain-ranges. Some geologists have regarded the slight depth of the surface as a strong argument against the theory. It seems to me that they are somewhat hasty in coming to this conclusion, that they do not take sufficiently into account our utter ignorance on many important points. It cannot be denied that the theory is surrounded with great and serious difficulties, but I submit that there is a difference between objections which cannot be met and difficulties which have not yet been solved; and I cannot help thinking that these difficulties, if treated as subjects for future investigation, will sooner or later be removed. The contraction theory is attractive not only from its beauty and its simple grandeur. It explains so many phenomena in the evolution of mountain-chains; so many apparently unconnected facts are grouped together by its guidance; that the reasons must be weighty indeed which shall lead us to reject it.

IX.—An Exposure of Middle and Newer Pleistocene Boulder Clay in Derby.

By R. M. Deeley, F.G.S.

SOME very interesting deposits of Pleistocene age have lately been exposed on the Burton Road, Derby. The road rises on the north side of Mill Hill, and near the top, at the height of 260 feet, cuts into a mass of Boulder-clay, which is, or was, well shown in the cuttings for the new roads leading into Byron Street. Another outlier of the same clay is exposed in Littleover Lane to the south-west. The main mass of the deposit cut into on the Burton Road is a red morainic clay with boulders; apparently a subaerial moraine subsequently modified by the passage over it of land ice. Unlike the tough, silty, red and blue aqueous Boulder Clays so plentifully spread over the Midland counties, it shows little or no signs of aqueous action. Sometimes it has a banded or streaked appearance, but this seems to be due rather to a crushing or pressing-out action than to original conditions of deposition. In this respect it much

resembles many of the morainic deposits of the Lake District and North Wales. Although the matrix is chiefly finely broken up Keuper Marl and Coal-measure rock, there are occasional beds of what appears to be torrential sand and gravel much disturbed by subsequent ice action. Large boulders of Upper Carboniferous rocks, together with quartzite pebbles, probably derived from the Bunter Pebble Beds, are abundant, but Carboniferous Limestone is rather scarce. Flints are numerous and sometimes of large size. They are scattered throughout the whole depth of the deposit, not merely intruded into the surface portions.

I have elsewhere pointed out[1] that in the Midlands flints are absent from the thick deposits of Older Pleistocene Boulder Clay and sand, but appear in great abundance in the clays and sands of Middle Pleistocene age. Associated with the Older Pleistocene Boulder Clays there occurs a thick deposit of sand, the Quartzose Sand, the false bedding of which indicates powerful currents from the north-west and south-west. The absence of flint from these deposits has a peculiarly interesting bearing upon the question of where the flints in the clays and sands of Wales, Cheshire, and Lancashire came from, and also when they were carried to the positions they now occupy. In Older Pleistocene times, when, as we have seen, the currents were favourable for the transport of flints from Ireland, flints were certainly not brought in any quantity into the Trent Valley. At least I have only found them in deposits of this age near the surface, into which they have no doubt been subsequently introduced. In Middle Pleistocene times, when the ice-flow was from the East or N.N.E., great quantities of flint and chalk were carried into the Trent Valley; for flints form a considerable proportion of the Chalky Sand even in the extreme north-westerly portion of the area; indeed they may be found in the Chalky Sand where it passes through the Biddulph Pass into the Cheshire Plain; but the nearer we approach the hypothetical Irish source, the more scarce they become. I do not mean to assert that no flints have crossed over from Ireland; but the weight of evidence points strongly to the conclusion that the vast majority of the flints in the Boulder Clays and sands of North and South Wales came from the east of England during the Middle Pleistocene epoch.

The presence of flint in the Burton Road and Littleover Boulder Clay, therefore, favours the assumption that the deposit is either of Middle or Newer Pleistocene age. Fortunately a deep excavation in the road, after passing through the red morainic clay, entered a couple of feet of blue silty clay full of rounded grains and pebbles of chalk. This deposit, which was clearly typical Chalky Boulder Clay, rested directly upon Keuper Marl, and was separated by a sharp line from the red clay above. Another shaft close by passed through clean-bedded Middle Pleistocene sand. Both the lithological and stratigraphical evidence, therefore, points to the conclusion that the upper clay is the Later Pennine Boulder Clay.[2]

[1] Q. J. G. S. Nov. 1886.

[2] That Mr. A. J. Jukes-Browne has misunderstood my argument concerning the

As I have recorded the presence of this deposit in many places in the neighbourhood of Derby, it is very satisfactory to find it resting in considerable masses upon, and separated by a sharp line of demarcation from, the Chalky Boulder Clay. It is evident from the great quantity of flint which exists in the Newer Pleistocene Boulder Clay and River Gravels of the Derwent Valley, at and below Derby, that the small patch of Chalky Boulder Clay on the side of Mill Hill is merely a remnant of a great mass of the same deposit which once partly choked up the Derwent, Trent, and other valleys, outliers of which are to be seen at Chellaston, Doveridge, and Hanbury Wood End.

39, Caversham Road, Kentish Town, N.W.

NOTICES OF MEMOIRS.

I.—The Mineral Wealth of Queensland. By R. L. Jack, F.G.S., F.R.G.S., Government Geologist. Brisbane, 1888. 8vo. pp. 71. With Map showing position of the Mineral Fields.

THIS book, written at the request of the Hon. the Minister for Mines and Works, gives a resumé of the mining statistics of the Colony, with an account of the mineral fields that have been or are being worked, of the geological formations in which they occur, the methods of working and of reducing them where the latter is done on the spot, as well as a list of the minerals associated with them, and a table of localities where minerals yet undeveloped are known to exist.

In 1887 about 400,000 oz. of gold were raised, of which less than 25,000 were of alluvial origin, the remainder being obtained by crushing stone containing from one to two ounces to the ton.

The wealthiest gold field is the Charters Towers, for which the returns given for 1887 are alluvial 317 oz., reef 151,060 oz. obtained by crushing 83,292 tons of quartz. The gold here is associated with pyrites, galena, and zinc-blende, and the yield per ton shows a slight increase at the deepest levels, the lowest of which is now 1400 ft.

Gold occurs in most parts of the Colony, but as far as at present known only in paying quantities near the coast in the southern half, while in the northern or tropical divison in the interior as well.

The most remarkable mine is that of Mount Morgan in the Rockhampton District. The Mount is a dome-shaped hill 1500 ft. above sea-level and 500 above the surrounding table-land, of which the

Newer Pleistocene Boulder Clays of Lincolnshire is evident from the following passage in his letter, which I quote. Referring to my short paper in the Geol. Magazine for October, 1888, he says, "He suggests, however, that some of the clays classed by me as Newer Glacial may really be older than the Chalky Boulder Clay, and he apparently finds great difficulty in accepting the occurrence of such Newer Glacial beds at elevations approaching 400 feet." My greatest difficulty, distinctly stated, was the supposed "*marine* aspect of the high level, brown, Boulder Clays." All Boulder Clays are certainly not marine, frequently not even aqueous.

rocks belong to the Carbonifero-Permian series, and are intersected in every direction by dykes of dolerite, rhyolite, etc. "The upper portion of Mount Morgan consists of a deposit varying from red and brown hæmatite on the one hand to a frothy, spongy cellular siliceous sinter on the other. Fine gold is disseminated throughout the mass," it has averaged of late 7 oz. to the ton, is *absolutely free from silver*. The mining operations are simply quarrying, and the gold is extracted by chlorination. The mine is estimated to be worth £16,000,000, while Messrs. Morgan Bros., the original proprietors, who gave their name to the Mount, are said to have sold the 640 acres it covers for less than £300.

The amount of silver obtained in 1887 was over £120.000 in value, chiefly from galena, though in the Ravenswood silver-field the surface yielded lead carbonate giving as much as 300 oz. of silver to the ton, lower levels of galena giving 2 oz., while at a depth of 650 ft. "the shaft bottomed on an antimony and copper ore somewhat resembling tetrahedrite in composition, but containing from 500 to 5000 oz. silver to the ton."

The tin, produced chiefly by mining and crushing porphyry, quartzite and chlorite dykes, though a considerable quantity is obtained from alluvial deposits, was valued at over £220,000 in 1887.

Copper is not worked to any great extent, though there are lodes of oxides, carbonates and sulphides, the latter containing in some cases both gold and silver in considerable quantities, which, to quote the author, "would be payable under favourable conditions," meaning, we presume, proper facilities for carriage, for in one place he instances freight to England £1 per ton of ore, while the carriage to the port of shipment was £4 per ton.

The other metals are mercury and cobalt, the ores of the latter are very rich, and promise to be very productive when the workings are extended. Antimony has been mined to a small extent.

The Coal-fields extend over thirty thousand square miles, occurring in the Carbonifero-Permian and Jurassic systems. The quality is good in some of the seams, but in others the percentage of ash is high. The workings at present are few, in fact only 230,000 tons were raised in 1887.

REVIEWS.

I.—Prof. Dr. von Zittel on Palichthyology.

Karl A. von Zittel, Handbuch der Palæontologie. Palæozoologie. Band III. Lief. I. II. (R. Oldenbourg, Munich, 1887–88.)

(*Concluded from page* 181.)

Teleostei.

THE only modern synopsis of the Palæontology of the Teleostean fishes, previous to the publication of Dr. v. Zittel's work, is to be found in Dr. Günther's "Study of Fishes" (1880); and as this is merely an outline, without details or references, the present

"Handbuch" supplies an important desideratum in Ichthyological literature. The description of the "subclass" occupies pp. 252–316, and is illustrated by 58 woodcuts.

After an enumeration of the more general works upon the subject, and a preliminary definition, the six "orders" of Johannes Müller are adopted, and the extinct representatives of each noticed in succession from the Lophobranchii to the Anacanthini.

The known fossil Lophobranchs are but few in number, and restricted to the Tertiaries. Of the Solenostomidæ an extinct representative (*Solenorhynchus*) occurs in the Eocene of Monte Postale; and the common surviving pipe-fish (*Syngnathus*) is met with in the Oligocene of Monte Bolca and Croatia, and in the Miocene of Licata, Sicily. A *Hippocampus*-like fish with a caudal fin (*Calamostoma*) has also been described by Agassiz from Monte Bolca.

The Plectognathi have a scarcely more satisfactory palæontological record, and only a few types, closely related to living genera, have hitherto been detected in the Tertiaries. Of the sun-fish (*Orthagoriscus*) Dr. v. Zittel rightly casts doubt upon Dixon's supposed fossil jaw from the Chalk, which now proves to be the dentary bone of a turtle;[1] but reference might have been made to the undoubted mandibles of *Orthagoriscus* discovered in the Oligocene of Belgium.[2] *Diodon* has a wide range from the Oligocene upwards, and there are some indications of closely-allied extinct genera in the Lower Tertiaries of Egypt, the Gironde, and Monte Postale. *Ostracion* occurs at Monte Bolca; and *Balistes* is supposed to be represented upon the same horizon by the extinct *Protobalistum*. Following Baron de Zigno, the author assigns two species to the latter genus, but Dr. Theodore Gill[3] has lately pointed out that a rearrangement is required, and that the so-called *P. Ombonii* forms the type of a very distinct genus to be henceforth termed *Protacanthodes*. *Acanthoderma* and *Acanthopleurus* are the well-known Scleroderms described by Agassiz from the black slates of the Canton Glarus; and, in default of a more certain position, the pharyngeal teeth named *Ancistrodon* (first determined as such by Dr. W. Dames) are provisionally placed as an appendix to the same group.

The great order of Physostomi commences with the family of Siluridæ, and the earliest undoubted representatives of this remarkable division are recorded from the Eocene. One extinct genus (*Bucklandium*) has lately been noticed in the London Clay of the Isle of Sheppey;[4] and a recent discovery of a nearly complete skull in the Barton Clay[5] has confirmed the occurrence of the recent genus *Arius* in the English Middle and Upper Eocenes. The genera from the Pliocene of the Siwalik Hills, India, and from the Lower Tertiary of Padang, Sumatra, are also satisfactorily determined; but the so-called *Pimelodus* from the Miocene of Hungary is based upon fin-

[1] Proc. Geol. Assoc. vol. x. p. 276.
[2] P. J. Van Beneden, Bull. Acad. roy. Belg. [3] vol. vi. (1883), p. 132.
[3] Amer. Nat. 1888, pp. 446–448.
[4] Geol. Mag. [3] Vol. V. p. 471; and Proc. Zool. Soc. April 2nd, 1889.
[5] E. T. Newton, Proc. Zool. Soc. April 2nd, 1889.

rays which appear quite indeterminable, and probably do not belong even to the Siluroid family.

Following the Siluridæ are the three typically-Cretaceous families of "Saurocephalidæ" (Saurodontidæ of Cope), Hoplopleuridæ, and Stratodontidæ. These, however, can only be regarded as provisionally defined, and the precise relationships even of the best-known genera are at present very doubtful. *Portheus*, *Ichthyodectes*, and *Saurocephalus* are typical representatives of the Saurocephalidæ: but, as Cope has already recognized,[1] it is impossible to place *Protosphyræna* with these. The stated definition of the Hoplopleuridæ contradicts one point ("Wirbelsäule verknöchert") in the diagnosis of the "subclass Teleostei" on p. 252; and this contradiction is introduced to admit of the association of the early Mesozoic genera, *Belonorhynchus* and *Saurichthys*, with *Dercetis* and its allies of the Chalk. Such an association appears to the present writer most unnatural and unjustifiable; for it must be remembered that in the dorsal and anal fins of *Belonorhynchus* the interspinous bones are very much fewer in number than the dermal rays[2]—a character unknown in any fishes higher than Crossopterygians and Acipenseroids—while the maxilla of *Saurichthys* has lately proved to exhibit a palatal extension such as has hitherto been met with only in the Crossopterygian *Polypterus*.[3] The Neocomian *Saurorhamphus*, it is true, is said to have possessed a persistent notochord, but more information is required concerning this fish. *Leptotrachelus* is probably a synonym of *Dercetis*, or at least is not separated by the usual diagnosis;[4] and in whatever family *Eurypholis* is placed, *Enchodus* must follow. *Eurygnathus* (Davis) is a synonym of the latter,[5] and the recent discovery of complete skulls has proved the stout bones so long described as premaxillæ (and thus named by Dr. v. Zittel) to be truly the palatine elements.[6] The amended "*Hypsodon*" is identical with *Pachyrhizodus*;[7] and next to *Cimolichthys* we might add *Pomognathus*,[8] removing it from p. 279.

The Esocidæ have few extinct representatives, so far as known, though there is much in their anatomy to suggest close alliance with some of the earlier Physostomi. The Notopteridæ and Chirocentridæ also have no fossil representatives of importance; but the enumeration of the succeeding Clupeidæ occupies nearly nine pages. Here Dr. v. Zittel places the typically Jurassic *Thrissops* and *Leptolepis*, adopting a subfamily Thrissopina, and then three others—the Clupeina, Chanina, and Elopina. A fine new figure of the head, opercular apparatus, and pectoral arch of *Leptolepis* is given; and there is some interesting information concerning the mandible both of this genus and of *Thrissops*. W. von der Marck's wide separation of *Sardinioides* from *Osmeroides* is accepted; *Scombroclupea* follows

[1] Bull. U.S. Geol. Surv. Territ. vol. iii. (1887), pp. 821–823.
[2] W. Deecke, Palæontogr. vol. xxxv. (1889), p. 129.
[3] Ann. and Mag. Nat. Hist. [6], vol. iii. 1889, p. 302.
[4] Proc. Geol. Assoc. vol. x. p. 319.
[5] Geol. Mag. [3], Vol. V. 1888, p. 472.
[6] Proc. Geol. Assoc. vol. x. p. 315, pl. i. figs. 5, 6.
[7] *Ibid.* p. 311. [8] *Ibid.* p. 317.

Clupea; and *Diplomystus* is recorded, but only from the Green River Shales of Wyoming. The latter genus is now known also from the Cretaceous of Brazil [1] and Mount Lebanon,[2] besides from the Oligocene of the Isle of Wight.[3]

The fossil Salmonidæ are little known, and to the author's account we would only add that the remarkable nodular concretions with *Mallotus villosus*, so well known from Greenland, are also met with in the Glacial Clays on the banks of the Ottawa River in Canada. The palæontological history of the Scopelidæ and Osteoglossidæ is likewise scanty; and the only point of much interest in that of the Cyprinodontidæ is the occurrence of the now-existing tropical American genus *Pœcilia*, in the Oeningen beds of Switzerland. Many representatives of the Cyprinidæ occur in freshwater Tertiary formations, but the majority are referable to existing genera; and *Notogoneus*, from the Green River shales of Wyoming, is the sole recognized fossil genus of Gonorhynchidæ (misprinted Ganorhynchidæ). The Murænidæ occur first in the Upper Cretaceous of Mount Lebanon; and the Scombresocidæ, which conclude the Physostomous order, are considered by Dr. v. Zittel to be also probably represented in the Cretaceous by *Istieus* and *Rhinellus*.

The order of Pharyngognathi comprises three families with fossil representatives—the Pomacentridæ, Labridæ, and Chromidæ. To the first are assigned two extinct genera, *Odonteus* from Monte Bolca; and *Priscacara* from the Green River Shales of Wyoming; and in the last are placed the Cretaceous genera *Pycnosterinx*, *Omosoma*, and doubtfully *Imogaster*. The Labridæ are represented chiefly by detached examples of the pharyngeal dentition in the Tertiaries; and in addition to typical forms like *Labrus* and *Nummopalatus*, Dr. v. Zittel places here the remarkable Eocene *Phyllodus* and *Egertonia*. The latter are also recorded from the Cretaceous, but *Phyllodus cretaceus*, Reuss, is not founded upon satisfactory evidence; and *Egertonia gaultina*, Cornuel, from the French Gault, is very doubtfully related to the Eocene fossils, and may perhaps be more satisfactorily compared with the palatine dentition of the Elopine *Protelops* from the Turonian of Bohemia.

The order Acanthopteri commences with the Berycidæ, having many extinct representatives. In addition to the ordinary species, *Beryx* includes numerous detached scales described under five or six generic names from the Plänerkalk of Saxony and Bohemia; and we would only remark that the English Chalk species mentioned (*B. lewesiensis*) now proves to be referable to *Hoplopteryx*.[4] In the last-named genus must also be placed the so-called *B. Zippei*, of the dorsal fin of which the figure copied from Fritsch scarcely gives a correct impression.[5] The Lebanon fossil named *Homonotus pulcher*

[1] E. D. Cope, Proc. Amer. Phil. Soc. vol. xxiii. (1886), p. 3.
[2] Ann. and Mag. Nat. Hist. [6] vol. ii. (1888), p. 134.
[3] *Clupea vectensis*, E. T. Newton, Quart. Journ. Geol. Soc. vol. xlv. (1889), pp. 112–117, pl. iv.
[4] Proc. Geol. Assoc. vol. x. p. 327.
[5] *Cf.* L. Agassiz, Poiss. Foss. vol. iv. pl. xv. fig. 2.

is probably a *Pycnosterinx*;[1] and *Platycormus* appears to have more affinity with the Squamipinnes than with the Berycidæ.

Like the last family, the Percidæ are also represented by many extinct species and a few extinct genera, but these appear to be restricted to Tertiary formations. The Glarus fossil, *Acanus*, is placed here as the result of Wettstein's researches; and the recent genus *Serranus* ranges downwards to the Eocene of Monte Bolca. Of freshwater genera, the common *Perca* has a wide range in the European Tertiaries; and *Smerdis* is a common extinct form in the Eocene and Miocene. The Pristipomatidæ are separated from the Percidæ, and the London Clay *Sciænurus* is assigned a place in this family.

Dr. v. Zittel's account of the Sparidæ is an interesting palæontological lesson; for the variation in the teeth of these fishes has led to the publication of innumerable names, which the ichthyologist soon recognizes as worthless and arising from ignorance of recent genera. *Capitodus*, Münster, is shown to be partly founded upon the anterior teeth of *Chrysophrys*, and partly upon the pharyngeal teeth of Cyprinoid fishes; most of the crushing teeth of *Chrysophrys* have been named *Sphærodus* and *Sparoides* by fossil collectors; and *Trigonodon*, Sismonda, is shown to be a synonym of *Sargus*. A new genus, *Stephanodus*, is founded upon broad cutting teeth with denticulated edges, from the Upper Chalk of the Sahara; and associated with these fossils are round crushing teeth, which seem to demonstrate the Sparoid affinities of the original fish. The Squamipinnes, Scorpænidæ, and Teuthididæ, are not of much palæontological interest; and, as Dr. v. Zittel remarks, the published information concerning the fossil Xiphiidæ is somewhat doubtful.[2] The Palæorhynchidæ form an entirely extinct family of older Tertiary age, and the author considers that *Hemirhynchus* is a synonym of *Palæorhynchus*, being originally founded upon an imperfect specimen. It is satisfactory, at last, to find no mention of *Enchodus* in a palæontological account of the Trichiuridæ; and Wettstein's determination of the identity of *Anenchelum* with *Lepidopus* is adopted, thus extending the range of this recent genus to the horizon of the Swiss Glarus slates.

Of the Acronuridæ the recent genera *Acanthurus* and *Naseus* are determined from Monte Bolca; and the little *Calamostoma* (Steindachner) from the same horizon requires a new name, not being the *Calamostoma* of Agassiz (p. 256).

The Carangidæ are represented by extinct species of the principal recent genera in the Tertiaries; and a few (e.g. *Platax*) also occur in the uppermost Cretaceous. Of the Cyttidæ, *Zeus* has been found in the Miocene of Licata, Sicily, and there is an extinct genus, *Cyttoides* (Wettstein), in the Glarus slates. A good figure of the well-known *Mene* (*Gasteronemus*) *rhombeus* is given under the Coryphænidæ; and the succeeding list of Scombridæ and Trachinidæ does not present much of interest, except the occurrence of the specialized

[1] Proc. Geol. Assoc. vol. x. p. 329.
[2] See Proc. Geol. Assoc. vol. x. p. 321.

Echeneis in the Glarus slates, as discovered by Wettstein. The Pediculati or Lophiidæ are still only known, among fossils, in the Eocene of Monte Bolca; and the Cottidæ, Cataphracti, Gobiidæ, and Blenniidæ, are soon enumerated, the only striking forms being the problematical *Petalopteryx* and *Cheirothrix* from Mount Lebanon. Among the Mugiliformes, the so-called *Sphyræna Amici*, of Mount Lebanon, is rightly omitted; but it may be added that both *Calamopleurus* and *Cladocyclus* are well known from the English Chalk,[1] and *Dictyodus* does not pertain to this family, but to the Scombridæ.[2] There is also some doubt concerning *Apsopelix*, Cope, for it is mentioned both here and in the Stratodontidæ (p. 269). The Blochiidæ, with the single remarkable extinct genus, *Blochius*, from Monte Bolca, follow the Mugiliformes; and the Aulostomi close the Acanthopteran series.

Of the important modern order Anacanthini, so few extinct forms are known that less than two pages suffice for their consideration. Both the Gadidæ and Pleuronectidæ range from the Eocene upwards, but much yet remains to be discovered concerning their ancestry and precise relationships.

In conclusion, Dr. v. Zittel devotes twenty pages to a general summary of our knowledge of the distribution of fossil fishes in space and time; and this unique work of reference is thus made available for the Stratigraphical Geologist equally with the systematic Ichthyologist. A. Smith Woodward.

II.—Brachiospongidæ: A Memoir on a Group of Silurian Sponges. With Six Plates. By Charles Emerson Beecher. Memoirs of the Peabody Museum of Yale University, Vol. ii. pt. i. (New Haven, Conn., 1889. Imp. 4to. 28 pp.)

THE peculiar sponges to which Prof. O. C. Marsh gave the name of *Brachiospongia* have been described and figured since 1838, but hitherto their structural characters have been unknown. Mr. Beecher has carefully studied the specimens obtained by Prof. Marsh, and, aided by this gentleman's liberality, has brought out the present beautifully illustrated Memoir, in which the real nature of these sponges is satisfactorily shown. The sponges themselves—which sometimes reach to a foot in diameter—consist of an open cup-shaped, central body, from which a number of curved, tubular finger-like processes project. The sponge-wall is built up of spicules of the hexactinellid type, which do not appear to be cemented together, with the exception of those forming the dermal layer, which are apparently fused into an irregular quadrate mesh. There is considerable variety in the outer form and the number of the projecting arms in different specimens, but Mr. Beecher has done wisely in regarding them as belonging to a single species, *B. digitata*, D. D. Owen, sp. Another hexactinellid sponge having a peculiar lobate or tuberous form and a stout wisp or rope of anchoring spicules is placed in a new genus *Strobilospongia*. These sponges have been

[1] Proc. Geol. Assoc. vol. x. pp. 324, 325.

[2] Dollo and Storms, Zool. Anzeiger, No. 279 (1888).

for the most part obtained in Kentucky and Tennessee, in passage-beds between the Trenton and Hudson River formations, apparently on the horizon of the Utica Shale, which in these States is not distinctively developed as a bituminous shale, the same as in New York and Canada. There is a definite horizon in Franklin County, Kentucky, in which they are associated with beds of cherty limestone, the chert being restricted to the bands in which the sponges occur. Their condition of preservation is as a rule unfavourable, and much credit is due to Mr. Beecher for having finally determined their structural characters.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 6, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Subdivisions of the Speeton Clay." By G. W. Lamplugh, Esq. Communicated by Clement Reid, Esq., F.G.S.

This paper gave the results of a long series of observations made during favourable opportunities at the cliff-foot and on the beach at Speeton from 1880 to 1889. The chief points brought forward by the author were as follows:—

The sandy blue shales now seen in the cliff near Filey are not in place, but are erratics in the Drift, and most, if not all, of them are derived from the Lias.

The bituminous shales with *Belemnites Owenii*, classified as Upper Kimeridge, extend upwards to the Coprolite-bed and the beds described as Portlandian by Prof. Judd, having been wrongly placed in this part of the section. No unconformity is traceable at the Coprolite-bed, or at any other horizon, between the Jurassic and Cretaceous portions of the clays.

The clays may be most conveniently divided into zones by reference to the Belemnites, as follows:—

Marly shales below the Red Chalk = zone of *B. minimus* and allies.

Upper division of the "Neocomian," including the "Cement-beds," and part of the Middle Neocomian of Judd = zone of *B. semicanaliculatus* and allies.

Lower division of the Neocomian from the top of the *Pecten cinctus* zone down to the base of the supposed Lower Neocomian zone of *Ammonites noricus* = zone of *B. jaculum*.

From the base of the *noricus*-zone to the Coprolite-bed = zone of *B. lateralis* (zone of *Amm. Astierianus* of Judd).

The bituminous shales below the Coprolite-bed = zone of *B. Owenii* and varieties.

The clays of the zone of *Bel. lateralis* have strongly marked Jurassic affinities, and it is from this zone that the coronated Ammonites were obtained, these being the beds supposed by Leckenby to be of Portlandian age. A very well-marked band of nodules,

with some scattered coprolitic pebbles, caps the *lateralis*-beds, and this band constituted the "Coprolite-bed" of Leckenby.

The thickness of the clays above the coprolites has been overestimated; it is probably not more than 300 feet.

The ranges which have been assigned to some of the characteristic fossils, especially *Ammonites Astierianus*, *Amm. speetonensis*, and *Toxaster complanatus*, need to be revised and altered.

The term "Middle Neocomian," as applied in the Speeton section, is unnecessary and misleading, seeing that a "Lower Neocomian" fauna occurs both above and below the beds with Middle Neocomian types; and, as stated by Meyer, marly shales exist between the Red Chalk and the Neocomian clays, strongly suggestive of a passage from the one to the other, and these beds contain many Gault forms. Thus there is probably at Speeton a continuous series of clays from the Jurassic to the Upper Cretaceous, and the deposition of these beds appears to have gone on contemporaneously with the erosion of the beds inland.

2. "Notes on the Geology of Madagascar." By the Rev. R. Baron. Communicated by the Director-General of the Geological Survey. With an Appendix on some Fossils from Madagascar, by R. Bullen Newton, Esq., F.G.S.

The central highlands of Madagascar consist of gneiss and other crystalline rocks, the general strike of which is parallel with the main axis of the island, and also, roughly, with that of the crystalline rocks of the mainland. The gneiss is frequently hornblendic; its orthoclase is often pink; triclinic felspar also occurs in places; biotite is the most common mica, but muscovite is not uncommon; magnetite is generally present, often in considerable quantities. The gneiss is often decayed to great depths, forming a red soil, and the loosened rock is deeply eaten into by streams. The harder masses of gneiss, having resisted decay, stand out in blocks, and have been mistaken for travelled boulders of glacial origin. Other more or less crystalline rocks are mica-schists, chlorite-schists, crystalline limestone, quartzite (with which graphite is often associated), and clay-slate.

Bosses of intrusive granite rise through the gneiss. That east of the capital contains porphyritic crystals of felspar which near the northern edge of the granite are arranged roughly in a linear direction; here also the granite contains angular fragments of gneiss. For the most part the granite of Madagascar is clearly intrusive, but this may not always be the case.

The volcanic rocks are of much interest. The highest mountains, those lying to the S.W. of the capital, consist in their higher parts, of a mass of lava, for the most part basaltic, but with some sanidine-trachyte. The lava-streams are sometimes 25 miles long, and successive flows, up to 500 feet in thickness, are exposed by the valleys. From the great denudation which this area has undergone, and from the fact that no cones now remain, we may assume that this volcanic series is of some antiquity. Of the newer volcanic series there are numerous very perfect cones, dotting the surface of the gneiss in

many places. No active volcano now exists in the island, but the occasional emission of carbonic-acid gas, the occurrence of numerous hot springs and deposits of siliceous sinter, and the frequency of small earthquake-shocks, seem to show that volcanic forces are only dormant and not entirely extinct.

The ashes generally lie most thickly on the side of the cone between north and west; this is accounted for by the prevalence of the south-east trade-winds. The volcanic areas are ranged roughly in a linear direction, corresponding with the longer axis of the island.

Sedimentary rocks occur mainly on the western and southern sides of the island. The relations of these to each other have not yet been determined; but from the fossils (referred to the European standard) it seems that the following formations are represented:—Eocene, Upper Cretaceous, Neocomian, Oxfordian, Lower Oolites, Lias. Possibly some of the slaty beds may turn out to be Silurian or Cambrian. The crystalline schists, etc., are probably, for the most part at least, Archæan. Recent deposits fringe the coasts and are largely developed on the southern part of the island.

East of the central line of watershed there is a long depression containing a wide alluvial deposit, probably an old lake-bed. Terraces fringe its sides in many places. The lagoons of the eastern coast are due to alluvial deposits.

The paper concluded with some remarks on the geological antiquity of the island, its separation dating from early Pliocene times, if not earlier. This is the conclusion arrived at by Wallace from its fauna; the author's detailed researches into its flora, recently described before the Linnean Society, show that while about five-sixths of its *genera* of plants are also found elsewhere, chiefly in tropical countries, at least four-fifths of its *species* are peculiar to Madagascar.

The Appendix, drawn up by Mr. R. Bullen Newton, F.G.S., consisted of Notes upon the fossils collected by the author, with tables, and descriptions of two new species, namely, *Astarte* (?) *Baroni* and *Sphæra madagascariensis*, both from deposits of Lower-Oolitic age.

3. "Notes on the Petrographical Characters of some Rocks collected in Madagascar by the Rev. R. Baron." By F. H. Hatch, Ph.D., F.G.S.

This paper was divided into two parts, the first treating of the petrographical characters of the older crystalline rocks of the eastern and mountainous part of the island, the second of the nature of the lavas that have been erupted from volcanic vents situated mainly in the same portion of the island.

i. *The Older Crystalline Rocks* are represented in Mr. Baron's collection partly by foliated specimens, partly by rocks showing no parallel structure in the hand-specimen.

The foliated specimens have, with few exceptions, the structure and composition of *gneiss*. The author subdivided them into an acid and a basic series. The acid series, which embraces rocks composed of abundant quartz with orthoclase as the dominant felspar,

he terms *granitite-gneiss*; the basic series, which consists of rocks containing little quartz and much plagioclase felspar, *tonalite-gneiss*.

The unfoliated specimens comprise *granite*, *gabbro* or *norite*, *pyroxene-granulite*, and *pyroxenite*.

The majority of the granites are of the *granitite*-type—*i.e.* they are *granites with one mica*; but *granites with two micas* are also represented.

The remainder of the rocks are of a basic type. They are interesting, in the first place, on account of the striking combinations of fresh and beautiful minerals they present, as for example:—plagioclase, hypersthene, olivine, brown hornblende and green spinel, in an *olivine-norite*; or, plagioclase, green pyroxene (omphacite or diallage), hypersthene, hornblende, garnet and iron-ore, in *pyroxene-granulite*; or, again, diallage and hypersthene in *pyroxenite*.

But of greater interest is the fact that these basic types, which are so well known in other territories of old crystalline rocks—Saxony, Brittany, Scandinavia, Scotland, the Hudson River, etc.—constitute in Madagascar, as they do at Kilima-njaro on the adjacent mainland, a large part of the ancient platform on the submerged portions of which the sedimentary rocks have accumulated, and through which the volcanic lavas were erupted.

ii. *The Volcanic Rocks.*—In composition these are acid, intermediate and basic, mainly the latter. The acid and intermediate types are described are *sanidine-trachyte* and *hornblende-augite-andesite*. The basic rocks consist of various types of *basalt*. They vary with respect to the presence or absence of corroded quartz-grains, olivine, porphyritic hornblende, and biotite. In one interesting type the hornblende appears in small idiomorphic crystals as a constituent of the ground-mass. A felspar-free variety, or *magma-basalt*, is also represented. This rock contains only a small quantity of olivine, and is therefore intermediate between Rosenbusch's *Limburgite* and Dölter's *augitite*.

II.—March 20, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Supplementary Note to a Paper on the Rocks of the Atlantic Coast of Canada." By Sir J. W. Dawson, K.C.M.G., F.R.S., F.G.S.

In a paper in the "Journal" for November, 1888, the author referred to the *Olenellus*-fauna as characterizing the Middle Cambrian. The fauna, he has no doubt, from the recently published observations of Walcott and Matthew, should be regarded as characteristic of the Upper Member of the Lower Cambrian. From this arises a new view of the physical geography of the period, namely, that the Lower Cambrian was, in America, a period of continental depression, and the Middle Cambrian a period of continental elevation, leading to the important conclusion that a time of elevation intervened between the Huronian and the early Cambrian, which may represent the apparent gap between these systems in Eastern America. He thinks that this new view deserves a special mention

in connection with the probability that the Huronian and Kewenian beds are of littoral origin.

2. "The Occurrence of Colloid Silica in the Lower Chalk of Berkshire and Wiltshire." By W. Hill, Esq., F.G.S., and A. J. Jukes-Browne, Esq., F.G.S.

In the Lower Chalk of Berks and Wilts are beds which contain a large amount of disseminated colloid silica; these are comparable in general structure to the Malmstones of the Upper Greensand. Dr. Hinde's study of the latter led him to believe that the globular colloid silica which they contain was directly derived from the remains of siliceous sponges, and the authors' studies of the Chalk specimens have confirmed this conclusion by adding several important pieces of evidence.

They found that the amount of free disseminated silica increases in proportion to the number of spicules and calcite-casts of spicules which occur in the rock, and observed that the great similarity between the siliceous chalk and the Malmstone was heightened by the occurrence of similar siliceous concretions in both rocks, the material of which might be described as siliceous chalk, indurated by a cement of chalcedonic silica. The conditions in which the silica was found in the Lower Chalk were described, in examples varying from those containing least to those which held most silica; in the latter the amount of colloid silica was estimated at 12·61 per cent. by weight. After noticing the vast amount of silica present in rocks with a maximum thickness of 70–80 feet, the authors discussed the difficulty of accounting for this, and drew attention to Prof. Sollas's statement that many living siliceous sponges constantly shed some of their spicules.

A further question arose as to whether the formation and accumulation of globular silica went on contemporaneously with the deposition of the calcareous material upon the sea-floor, or whether the conversion of the spicules into such silica took place after the consolidation of the rock, and the authors gave reasons for supposing that the latter was the case, the change having occurred when the rock was in a sufficiently oozy condition to admit of easy molecular distribution. Reasons were given for supposing that the disseminated colloid silica had not been derived directly from the disintegration of spicules in which a globular structure had been previously developed, but that the globular silica was precipitated from solution whilst the beds were still permeated by sea-water.

The precipitation of the chalcedonic silica was regarded by the authors as a secondary and subsequent operation. They were disposed to regard all nodular concretions resembling flints and phosphatic nodules as growths, which were more or less contemporaneous with the deposition of the materials of the enclosing rock, and in conclusion they offered some comments upon the problem of the formation of flints.

3. "Note on the Pelvis of *Ornithopsis*." By Prof. H. G. Seeley, F.R.S., F.G.S.

The remains preserved in Mr. Leeds's collection at Eyebury, and

described by Mr. Hulke, are the largest and most perfect pelvic bones of a Saurischian known in this country. An examination showed that the bones of the right and left sides were united in the median line almost throughout their length by a median suture, and that they formed a saddle-shaped surface internally from front to back. After giving a detailed description of the pubis and ischium, the author stated that he was not aware that this type of pelvis had been previously observed. He noted that the antero-posterior concavity between the anterior symphysis of the pubic bones and the posterior symphysis of the ischia was a well-marked characteristic of Saurischian reptiles, but that it remained to be determined to what extent the median union of the pubic bones was developed in the group.

It was impossible to judge of the form of the ilium from the imperfect fragment preserved, but it did not make any recognizable approximation to the bone in those American genera which offered the closest resemblance of form to the pubis and ischium.

There were several minor differences of proportion between the bones from the Oxford Clay and those from the Wealden of the Isle of Wight, and the former differed in ways pointed out from *Morosaurus*, *Diplodocus*, and *Brontosaurus*, though there were resemblances.

III.—April 3, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

The President announced that according to a circular lately received from the "Sociéte Géologique de France," that Society proposed to hold its Extraordinary Meeting this year in Paris, the date being fixed for the 18th August next. Meetings will be held in Paris, the collections in that city will be visited, and there will be a series of excursions to places of interest within easy reach of Paris, on successive days of the week devoted to the Meeting. These are specified on the circular; and in the week following the Meeting, excursions will be made to more distant localities, of which the Auvergne and Brittany are particularly mentioned, that to the former district under the guidance of M. Michel-Lévy, and that to Brittany conducted by M. C. Barrois. Arrangements will be made with the railway authorities for a reduction of 50 per cent. upon the fares; but in order to secure this advantage the names of persons intending to attend must be sent to the Secretaries of the Society before the 1st July, 1889. British Geologists, and especially Fellows of the Society, are cordially invited to be present.

The following communications were read:—

1. "The Elvans and Volcanic Rocks of Dartmoor." By R. N. Worth, Esq., F.G.S.

The object of this paper was to give reasons for the belief that the present granite of Dartmoor passed upward into felsitic and volcanic rocks, remnants of which are to be found in the Triassic conglomerate of Devon, in the detritus of the bottom lands of the moor itself, on the beaches of the channel, and in ancient river-gravels and pebble-beds; to indicate the wide range of character taken by the

felsites of the Dartmoor district; and to point out some of the evidence which exists in the *in-situ* elvans for the development of the most varied of these forms from a common magma.

Special opportunities for the study of two of the elvanite dykes in the neighbourhood of Tavistock have lately presented themselves. The Shillamill elvan exhibits a centre composed of quartzose felspar-porphyry graduating laterally through numerous varieties into "claystone porphyry"; whilst the Grenofen elvan retains the same structure in breadth, but changes in length from a rock containing so little felsitic matter that it is essentially a fine-grained porphyritic granite, to one with a compact semivitreous ground-mass, in which felspars, quartz, mica are porphyritically developed.

As evidence afforded of the existence of distinctly volcanic rocks, mention is made of a deposit of water-borne and water-worn detritus, indicating a Dartmoor origin for a large portion of its constituents, along with rolled flints and pebbles of Carboniferous, Liassic, and Cretaceous limestone, with which were associated typical andesites and specimens of volcanic grit such as arise from denudation of volcanic cones. This occurs on the limestone at Cattedown near Plymouth, and bears testimony to a very ancient denudation.

2. The "Basals of Eugeniacrinidæ." By F. A. Bather, Esq., B.A., F.G.S.

Although Professors Beyrich and v. Zittel had alluded to certain specimens of *Eugeniacrinus* as proving, by the course of the axial canals, that in this genus the basals had passed up into the radials, yet the two chief authorities who subsequently discussed the subject practically ignored this argument. M. de Loriol contented himself with denying any trace of basals, while Dr. P. H. Carpenter maintained that the top stem-joint represented a fused basal ring. In a previous paper the author had argued in favour of Prof. v. Zittel's view without convincing Dr. Carpenter of its correctness. Such scepticism was, no doubt, warranted by the lack of detailed description and of figures. The object of the present note was to set the matter at rest by describing and figuring certain dorsal cups of *Eug. caryophyllatus* kindly lent to the author by Prof. von Zittel.

Owing to the mode of fossilization the canal system is plainly seen. The axial canal passes up into the radial circlet and gradually widens; at a short distance below the floor of the calycal cavity it gives off five interradial branches; these soon bifurcate, and the adjacent radial branches converge. Before they meet, each radial branch gives off a very short branch; this connects the radial branch with the ring-canal that contained the interradial and intra-radial commissures.

The evidence of all other Crinoids that have these canals shows that the basals always contain the interradial branches. And in *Eugeniacrinus*, since the interradial branches have their origin in the middle of the radials, the basals must have passed up in between the radials.

3. "On some Polyzoa from the Inferior Oolite of Shipton Gorge, Dorset." By E. A. Walford, Esq, F.G.S.

The author referred to the little attention the Jurassic Polyzoa have received in England, a few scattered papers comprising the whole of the literature of the subject. This may be accounted for, in part, by the rare occurrence of conditions favourable to the preservation of the delicate features necessary for their true study, and in part, also, by the difficulties into which the classification has drifted.

The series dealt with has been collected from the Inferior Oolite, zone of *Ammonites Parkinsoni*, at Shipton Gorge, Dorset, and the number of forms from the single horizon and locality was stated to be equal to the whole of those described by Jules Haime from the Lias to the Kimeridge Clay. Associated with the Polyzoa are *Crania Moorei*, and sp., *Thecidea*, sp., *Rhynchonella senticosa*, *Terebratula Phillipsii*, *Ammonites Martinsii*, some Echinoderms, and a large series of sponges. The tranquil conditions prevailing during the deposition of the beds are indicated by the presence of many slender and arborescent forms of Polyzoa, and the little abrasion they have suffered, as well as by the presence of numerous sponges.

The author, in briefly reviewing the Cyclostomata, adopts the simple divisions of Mr. Waters, the Parallelata and Rectangulata, based upon the Hincksian system. The disregard of zoarial growth, in any great degree, as a means of classification, would lead to confusion under the present modes of grouping; neither, however, can any great constancy be found in the form of the zoœcia or in the shape of the aperture.

In the group *Stomatopora* six species are recognized, of which two are new. Amongst the *Proboscinæ* is a species described in that stage of growth as *Proboscina spatiosa*, which passes into both Tubuliporoid and Diastoporoid forms, and also in the latter phase throws off erect Entalophoroid branches. The author has used the same specific name for each form, though describing them under different generic names. Considerable variation in size and shape of cell occurs in each stage. The *Idmoneæ* are represented by two new species and two new varieties; *Bisidmonea* by one form only. Though the latter has much the appearance of *Entalophora*, the character of the ovicell is so definitely that of the associated *Idmonea* as to decide its relationship, and it has also the cell-type of *Idmonea*. In the group *Entalophora* d'Orbigny's Cretaceous species *Entalophora raripora* and *E. subgracilis* are quoted, the latter, however, under a varietal form. *E. anomala*, Manz., *E. richmondiensis*, Vine, and one new species, *E. magnipora*, complete the list so far.

MISCELLANEOUS.

Western Australia.—From Reports received, it appears that the Gold-fields of this Colony are likely to prove as rich as those of Eastern Australia. But we are still more glad to learn that the Coal-seams on the Irwin River, noticed by Gregory in 1863, are now being successfully worked, and promise excellent results. Western Australia has already 450 miles of railroad, and if coal can be obtained close to the northern terminus at Geraldton, it will be of the highest value.